Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supporting Information

Visible-light-induced bromine radical initiate direct C−H alkylation of heteroaromatic

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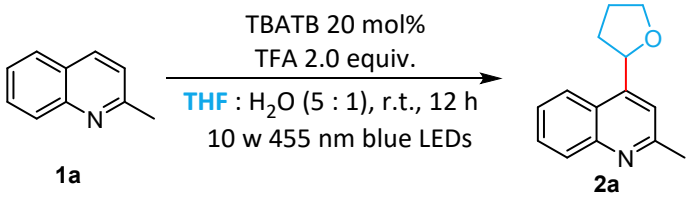
1. General considerations

General. Unless otherwise noted, all reactions were carried out under an air atmosphere. Analytical thin-layer chroma-tography (TLC) was performed on glass plates coated with 0.25 mm 230–400 mesh silica gel containing a fluores-cent indicator. Visualization was accomplished by exposure to a UV lamp. All the products in this article are compatible with standard silica gel chromatography. Column chromatography was performed on silica gel (200–300 mesh). Eluent generally contained ethyl acetate (EA), petroleum ether (PE).

Structural analysis. NMR spectra were measured on a Bruker Ascend 400 spectrometer and chemical shifts (δ) are reported in parts per million (ppm). ^{1}H NMR spectra were recorded at 400 MHz in NMR solvents and referenced internally to corresponding solvent resonance, ^{13}C NMR spectra were recorded at 101 MHz, ^{19}F NMR spectra were recorded at 376 MHz, and referenced to corresponding solvent resonance. Coupling constants are reported in Hz with multiplicities denoted as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet) and br (broad). Infrared spectra were collected on a Thermo Fisher Nicolet 6700 FT-IR spectrometer using ATR (Attenuated Total Reflectance) method. Absorption maxima (ν max) are reported in wavenumbers (cm^{-1}). High resolution mass spectra (HRMS) were acquired on Thermo Scientific LTQ Orbitrap XL with an ESI source. Melting points were measured with a micro-melting point apparatus.

Materials. Commercial reagents and solvent were purchased from Adamas, J&K, Energy, Aladdin, Alfa Aesar, Macklin, Organics, TCI, Innochem and used as received unless otherwise stated.

2. General procedure



A flame-dried 25 mL quartz reaction tube was placed with a magnetic stir bar. Then, 2-methylquinoline (28.6 mg, 0.2 mmol, 1.0 equiv.), tetrabutylammonium tribromide (19.3 mg, 0.04 mmol, 20.0 mol%), trifluoroacetic acid (45.6 mg, 0.4 mmol, 2.0 equiv.), THF (2.0 mL) and H_2O (400 μL) were added to the tube. The reaction tube was placed on a photocatalytic parallel reactor with Blue LEDs (10 W) at the bottom (**Figure S1**). Then the reaction mixture was stirred and irradiated with the Blue LEDs for 12 hours at room temperature.

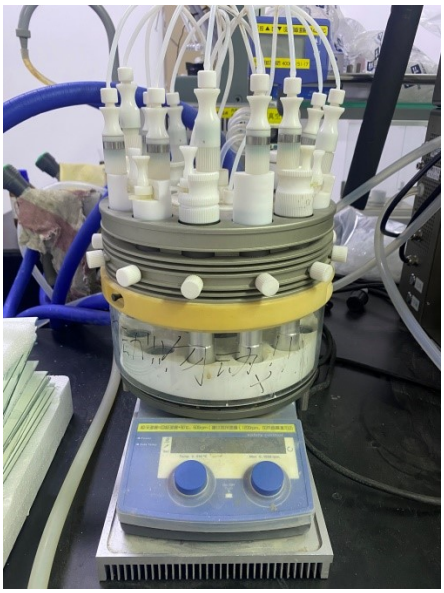


Figure S1. Picture of the reactor

After taking the reaction tube out, 10 mL saturated $NaHCO_3$ solution was added to the reaction mixture. Then, the reaction mixture was extracted with ethyl acetate (3 × 10 mL). The combined organic phase was washed with brine (2 × 5.0 mL) and then dried over anhydrous Na_2SO_4. After concentration, the crude product was purified by column chromatography (silica gel) to give the target product, using petroleum ether / ethyl acetate as the eluent.

3. Radical inhibition experiment

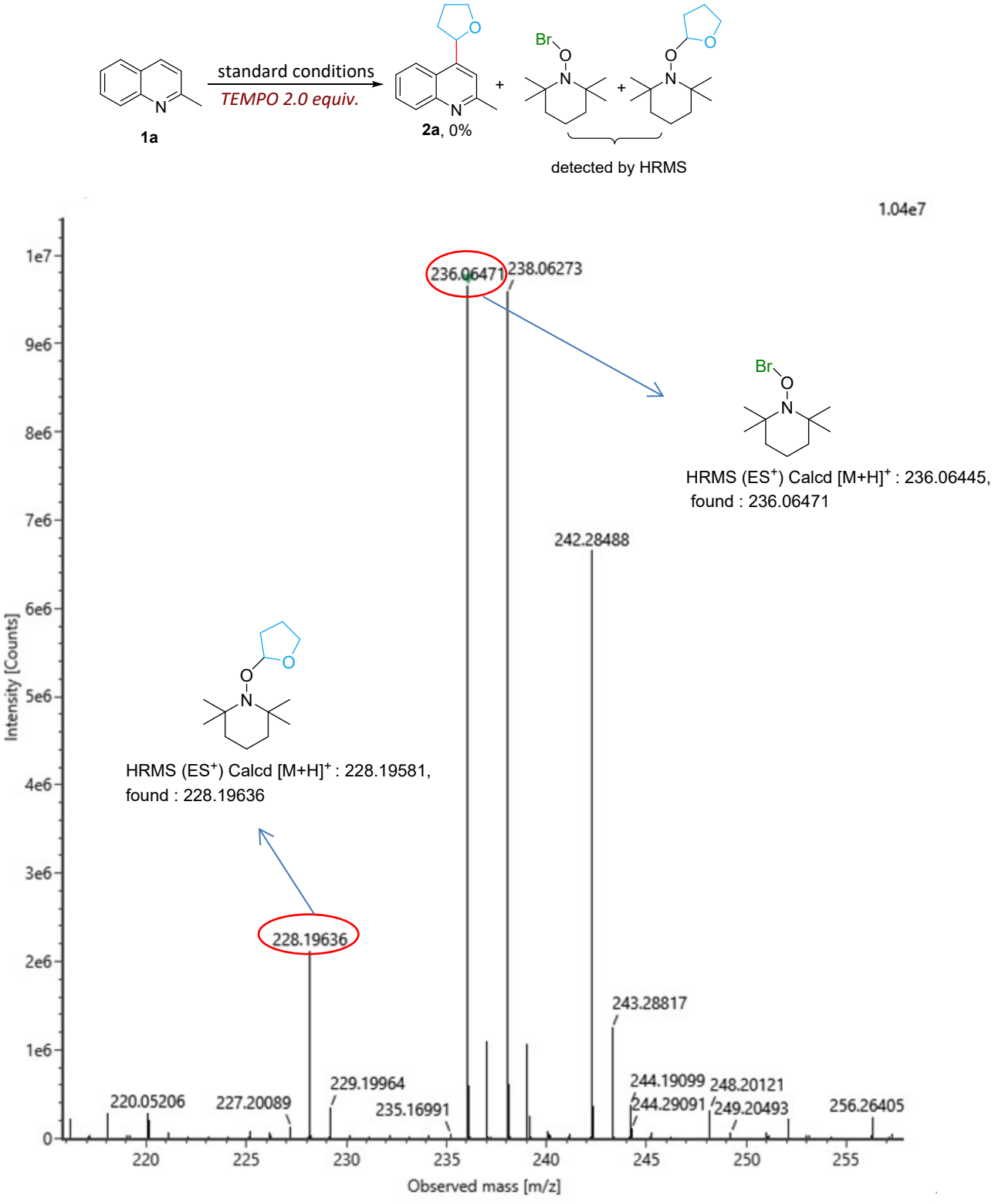
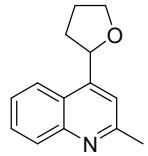


Figure S2. HRMS spectra for Radical inhibition experiment.

4. Characterization data

(**2a**) 2-Methyl-4-(tetrahydro-2-furanyl)quinolone (CAS: 104293-35-8)[1]



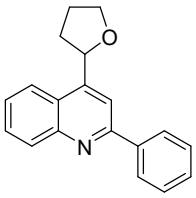
2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{15}NO$
Exact Mass: 213.1154
Molecular Weight: 213.2800

Following the General Procedure A with 2-methylquinoline (28.6 mg, 0.2 mmol), **2a** was obtained as colorless liquid (36.3 mg, 85%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, J = 8.4 Hz, 1H), 7.84 (d, J = 8.4 Hz, 1H), 7.66 (t, J = 8.0 Hz, 1H), 7.49 – 7.44 (m, 2H), 5.58 – 5.55 (m, 1H), 4.25 – 4.21 (m, 1H), 4.06 – 4.01 (m, 1H), 2.74 (s, 3H), 2.64 – 2.56 (m, 1H), 2.11 – 1.96 (m, 2H), 1.87 – 1.79 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.0, 149.4, 147.8, 129.3, 128.9, 125.5, 123.8, 122.9, 117.2, 76.7, 68.9, 33.8, 25.9, 25.4.

(**2b**) 2-Phenyl-4-(tetrahydro-2-furanyl)quinolone (1869978-48-2)[2]



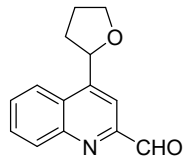
2-phenyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{19}H_{17}NO$
Exact Mass: 275.1310
Molecular Weight: 275.3510

Following the General Procedure A with 2-phenylquinoline (41.0 mg, 0.2 mmol), **2b** was obtained as colorless oil (40.2 mg, 73%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 – 8.20 (m, 3H), 8.06 (s, 1H), 7.90 (d, J = 8.4 Hz, 1H), 7.74 – 7.70 (m, 1H), 7.56 – 7.52 (m, 3H), 7.49 – 7.45 (m, 1H), 5.68 – 5.64 (m, 1H), 4.31 – 4.25 (m, 1H), 4.11 – 4.05 (m, 1H), 2.70 – 2.61 (m, 1H), 2.13 – 1.98 (m, 2H), 1.94 – 1.86 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.3, 149.9, 148.3, 139.9, 130.5, 129.2, 129.1, 128.7, 127.6, 126.0, 124.5, 123.0, 114.3, 69.0, 34.0, 26.0.

(**2c**) 4-(Tetrahydrofuran-2-yl)quinoline-2-carbaldehyde



4-(tetrahydrofuran-2-yl)quinoline-2-carbaldehyde
Chemical Formula: $C_{14}H_{13}NO_2$
Exact Mass: 227.0946
Molecular Weight: 227.2630

Following the General Procedure A with quinoline-2-carbaldehyde (31.4 mg, 0.2 mmol), **2c** was obtained as white solid (15.5 mg, 34%), R_f = 0.3 (petroleum ether/ethyl acetate = 5:1).

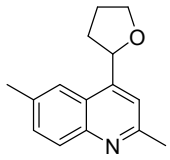
^{1}H NMR (400 MHz, $CDCl_3$) δ 10.22 (s, 1H), 8.27 (d, J = 8.4 Hz, 1H), 8.18 (s, 1H), 8.00 (d, J = 8.8 Hz, 1H), 7.83 – 7.79 (m, 1H), 7.71 – 7.67 (m, 1H), 5.66 – 5.62 (m, 1H), 4.30 – 4.25 (m, 1H), 4.10 – 4.04 (m, 1H), 2.68 – 2.60 (m, 1H), 2.10 – 2.02 (m, 2H), 1.91 – 1.83 (m, 1H).

^{13}C NMR 101 MHz, $CDCl_3$) δ 194.0, 152.5, 151.3, 148.0, 131.3, 130.0, 128.9, 127.6, 127.4, 123.5, 112.9, 69.1, 33.9, 26.0.

Melting point (℃): 100.3 – 102.7 ℃.

IR: 3375, 3059, 2988, 2955, 2878, 1697, 1593, 1512, 1458, 1360, 1151, 771, 650, 461. HRMS (ESI) m/z calcd for $C_{14}H_{13}NO_2$ $[M+H]^+$: 228.10191, found: 228.10185.

(**2d**) 2,6-Dimethyl-4-(tetrahydrofuran-2-yl)quinolone (2378441-92-8)[3]



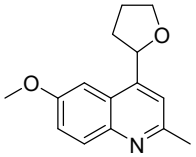
2,6-dimethyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{15}H_{17}NO$
Exact Mass: 227.1310
Molecular Weight: 227.3070

Following the General Procedure A with 2,6-dimethylquinoline (31.4 mg, 0.2 mmol), **2d** was obtained as colorless oil (20.0 mg, 44%), R_f = 0.2 (petroleum ether/ethyl acetate = 4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.94 (d, J = 8.4 Hz, 1H), 7.58 (s, 1H), 7.49 (d, J = 8.4 Hz, 1H), 7.40 (s, 1H), 5.54 (t, J = 7.2 Hz, 1H), 4.24 – 4.19 (m, 1H), 4.06 – 4.00 (m, 1H), 2.71 (s, 3H), 2.63 – 2.56 (m, 1H), 2.52 (s, 3H), 2.12 – 1.95 (m, 2H), 1.87 – 1.78 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.0, 148.7, 146.3, 135.2, 131.1, 129.0, 123.8, 122.0, 117.1, 76.7, 68.9, 33.8, 25.9, 25.3, 21.8.

(**2e**) 6-Methoxy-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2378441-93-9)[4]



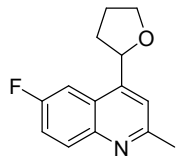
6-methoxy-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{15}H_{17}NO_2$
Exact Mass: 243.1259
Molecular Weight: 243.3060

Following the General Procedure A with 6-methoxy-2-methylquinoline (34.6 mg, 0.2 mmol), **2e** was obtained as white solid (33.6 mg, 69%), R_f = 0.1 (petroleum ether/ethyl acetate = 4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 9.2 Hz, 1H), 7.40 (s, 1H), 7.33 (dd, J =9.2, 2.4 Hz, 1H), 7.08 (d, J =2.8 Hz, 1H), 5.48 (t, J = 7.2 Hz, 1H), 4.25 – 4.19 (m, 1H), 4.06 – 4.00 (m, 1H), 3.91 (s, 3H), 2.70(s, 3H), 2.63 – 2.55 (m, 1H), 2.11 – 2.05 (m, 1H), 2.04 – 1.96 (m, 1H),1.89 – 1.82 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.9, 156.3, 148.0, 143.7, 130.6, 124.6, 120.6, 117.4, 102.0, 76.8, 68.9, 55.5, 33.4, 25.9, 25.1.

(**2f**) 6-Fluoro-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2095358-07-7)[4]



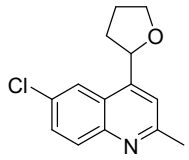
6-fluoro-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}FNO$
Exact Mass: 231.1059
Molecular Weight: 231.2704

Following the General Procedure A with 6-fluoro-2-methylquinoline (32.2 mg, 0.2 mmol), **2f** was obtained as white solid (24.5 mg, 53%), R_f = 0.3 (petroleum ether/ethyl acetate = 5:1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.02 (dd, J = 8.8, 5.6 Hz, 1H), 7.45 – 7.39 (m, 3H), 5.42 (t, J = 7.2 Hz, 1H), 4.23 – 4.18 (m, 1H), 4.05 – 3.99 (m, 1H), 2.70 (s, 3H), 2.61 – 2.53 (m, 1H), 2.12 – 2.04 (m, 1H), 2.03 – 1.94 (m, 1H), 1.85 –1.76 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.7 (d, J = 247.2 Hz), 158.3 (d, J = 2.7 Hz), 148.6 (d, J = 5.5 Hz), 145.0, 131.7 (d, J = 9.2 Hz), 124.4 (d, J = 9.3 Hz), 118.8 (d, J = 25.5 Hz), 117.9, 106.8 (d, J = 22.6 Hz), 76.7, 68.9, 33.6, 25.9, 25.3.
^{19}F NMR (376 MHz, $CDCl_3$) δ -113.8.

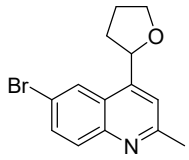
(**2g**) 6-Chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2378441-89-3)[4]



6-chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}ClNO$
Exact Mass: 247.0764
Molecular Weight: 247.7220

Following the General Procedure A with 6-chloro-2-methylquinoline (35.5 mg, 0.2 mmol), **2g** was obtained as white solid (34.7 mg, 70%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, J = 9.2 Hz, 1H), 7.78 (d, J = 2.0 Hz, 1H), 7.58 (dd, J = 8.8, 2.0 Hz, 1H), 7.44 (s, 1H), 5.45 (t, J = 7.2 Hz, 1H), 4.20 (dd, J = 13.6, 7.6 Hz, 1H), 4.03 (dd, J = 14.8, 7.2 Hz, 1H), 2.71 (s, 3H), 2.64 – 2.55 (m, 1H), 2.14 – 2.05 (m, 1H), 2.04 – 1.95 (m, 1H), 1.85 – 1.76 (m, 1H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 148.5, 146.2, 131.2, 130.9, 129.7, 124.6, 122.1, 118.0, 76.5, 68.9, 33.8, 25.9, 25.4.

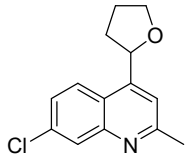
(**2h**) 6-Bromo-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2095358-06-6)[4]



6-bromo-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}BrNO$
Exact Mass: 291.0259
Molecular Weight: 292.1760

Following the General Procedure A with 6-bromo-2-methylquinoline (44.4 mg, 0.2 mmol), **2h** was obtained as white solid (43.8 mg, 75%), R_f = 0.2 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, J = 2.0 Hz, 1H), 7.89 (d, J = 9.2 Hz, 1H), 7.71 (dd, J = 8.8, 2.0 Hz, 1H), 7.44 (s, 1H), 5.45 (t, J = 7.2 Hz, 1H), 4.23–4.17 (m, 1H), 4.02 (dd, J = 15.2, 7.2 Hz, 1H), 2.70 (s, 3H), 2.64 – 2.54 (m, 1H), 2.13 – 2.05 (m, 1H), 2.03 – 1.95 (m, 1H), 1.85 – 1.76 (m, 1H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.5, 148.5, 146.4, 132.3, 131.0, 125.4, 125.1, 119.4, 118.0, 76.5, 68.9, 33.8, 25.9, 25.4.

(**2i**) 7-Chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (1821239-62-6)[4]

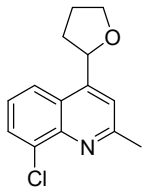


7-chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}ClNO$
Exact Mass: 247.0764
Molecular Weight: 247.7220

Following the General Procedure A with 7-chloro-2-methylquinoline (35.5 mg, 0.2 mmol), **2i** was obtained as white solid (26.3 mg, 53%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, J = 1.6 Hz, 1H), 7.77 (d, J = 8.8 Hz, 1H), 7.43 – 7.40 (m, 2H), 5.49 (t, J = 7.2 Hz, 1H), 4.20 (dd, J = 14.0, 8.0 Hz, 1H), 4.02 (dd, J = 15.2, 7.2Hz, 1H), 2.71 (s, 3H), 2.61 – 2.53 (m, 1H), 2.12 – 2.04 (m,1H), 2.03 – 1.95 (m, 1H), 1.84 – 1.75 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.3, 149.4, 148.4, 134.8, 128.3, 126.3, 124.3, 122.3, 117.4, 76.6, 69.0, 33.8, 25.9, 25.5.

(**2j**) 8-Chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2378441-96-2)[4]



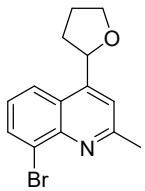
8-chloro-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}ClNO$
Exact Mass: 247.0764
Molecular Weight: 247.7220

Following the General Procedure A with 8-chloro-2-methylquinoline (35.5 mg, 0.2 mmol), **2j** was obtained as white solid (27.2 mg, 55%), R_f = 0.5 (petroleum ether/ethyl acetate = 5:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 – 7. 76 (m, 2H), 7.51 (s, 1H), 7.39 (t, J = 8.0 Hz, 1H), 5.54 (t, J = 7.2 Hz, 1H), 4.23 (q, J = 7.6 Hz, 1H), 4.04 (q, J = 7.2 Hz, 1H), 2.82 (s, 3H), 2.64 – 2.56 (m, 1H), 2.13 – 2.05 (m, 1H), 2.04 – 1.95 (m, 1H), 1.86 – 1.77 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.2, 149.7, 144.2, 133.5, 129.1, 125.3, 125.2, 122.1, 118.1, 76.7, 69.0, 33.9, 25.93, 25.91.

(**2k**) 8-Bromo-2-methyl-4-(tetrahydrofuran-2-yl)quinolone (2378441-97-3)[4]



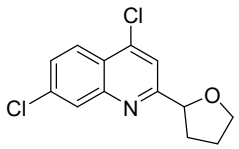
8-bromo-2-methyl-4-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{14}H_{14}BrNO$
Exact Mass: 291.0259
Molecular Weight: 292.1760

Following the General Procedure A with 8-bromo-2-methylquinoline (44.4 mg, 0.2 mmol), **2k** was obtained as white solid (39.7 mg, 68%), R_f = 0.5 (petroleum ether/ethyl acetate = 5:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, J = 7.6 Hz, 1H), 7.80 (d, J = 8.4 Hz, 1H), 7.48 (s, 1H), 7.30 (t, J =8.4 Hz, 1H), 5.53 (t, J = 7.2 Hz, 1H), 4.20 (dd, J = 15.2, 8.0 Hz, 1H), 4.02 (q, J =9.6 Hz, 1H), 2.80 (s, 3H), 2.62 – 2.55 (m, 1H), 2.10 – 2.05 (m, 1H), 2.02 – 1.95 (m, 1H), 1.83 – 1.77 (m, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.4, 149.7, 145.0, 132.7, 125.7, 125.22, 125.18, 122.8, 118.1, 76.7, 69.0, 34.0, 25.9, 26.0.

(**2l**) 4,7-Dichloro-2-(tetrahydrofuran-2-yl)quinolone (2306793-11-1)[1]



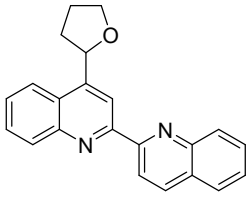
4,7-dichloro-2-(tetrahydrofuran-2-yl)quinoline
Chemical Formula: $C_{13}H_{11}Cl_2NO$
Exact Mass: 267.0218
Molecular Weight: 268.1370

Following the General Procedure A with 4,7-dichloroquinoline (39.6 mg, 0.2 mmol), **2l** was obtained as colorless oil (33.2 mg, 62%), R_f = 0.1 (petroleum ether/ethyl acetate = 4:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, J = 9.2 Hz, 1H), 8.06 (s, 1H), 7.70 (s, 1H), 7.55 – 7.52 (m, 1H), 5.14 – 5.11 (m, 1H), 4.17 – 4.11 (m, 1H), 4.06 – 4.00 (m, 1H), 2.55 – 2.47 (m, 1H), 2.09 – 1.99 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 165.1, 148.5, 143.4, 136.5, 128.1, 128.0, 125.4, 124.0, 118.4, 81.2, 69.3, 33.2, 25.8.

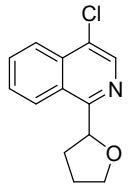
(**2m**) 4-(Tetrahydrofuran-2-yl)-2,2'-biquinoline



4-(tetrahydrofuran-2-yl)
-2,2'-biquinoline
Chemical Formula: $C_{22}H_{18}N_2O$
Exact Mass: 326.1419
Molecular Weight: 326.3990

Following the General Procedure A kwith 2,2'-biquinoline (51.3 mg, 0.2 mmol), **2m** was obtained as yellow oil (26,8 mg, 41%), R_f = 0.6 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.96 (s, 1H), 8.84 (d, *J* = 8.8 Hz, 1H), 8.33 – 8.28 (m, 3H), 8.0 (d, *J* = 8.4 Hz, 1H), 7.88 (d, J = 8.0 Hz, 1H), 7.77 – 7.74 (m, 2H), 7.60 – 7.56 (m, 2H), 5.69 (t, *J* = 7.2 Hz, 1H), 4.39 (q, *J* = 14.4 Hz, 1H), 4.13 (q, *J* = 14.8 Hz, 1H), 2.71 – 2.63 (m, 1H), 2.17 – 2.10 (m, 2H), 2.05 – 1.97 (m, 1H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 156.4, 156.2, 149.8, 148.1, 148.0, 136.6, 130.8, 130.1, 129.4, 129.0, 128.4, 127.6, 126.9, 126.7, 125.9, 123.4, 119.5, 114.9, 77.4, 69.0, 33.8, 26.1.
IR: 2960, 2926, 2853, 1462, 1261, 1094, 1018, 800.
HRMS (ESI) m/z calcd for $C_{22}H_{18}N_2O$ $[M+H]^+$: 327.14919, found: 327.14893.

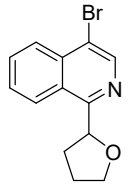
(**2n**) 4-Chloro-1-(tetrahydrofuran-2-yl)isoquinoline



4-chloro-1-(tetrahydrofuran-2-yl)
isoquinoline
Chemical Formula: $C_{13}H_{12}ClNO$
Exact Mass: 233.0607
Molecular Weight: 233.6950

Following the General Procedure A with 4-chloroisoquinoline (37.2 mg, 0.2 mmol), **2n** was obtained as yellow oil (29.0 mg, 62%), R_f = 0.5 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54 (s, 1H), 8.37 (d, *J* = 8.4 Hz, 1H), 8.23 (d, *J* = 8.4 Hz, 1H), 7.80 (t, *J* = 8.0 Hz, 1H), 7.67 (t, *J* = 8.0 Hz, 1H), 5.68 (t, *J* = 7.2 Hz, 1H), 4.18 – 4.12 (m, 1H), 4.05 – 3.99 (m, 1H), 2.56 – 2.48 (m, 1H), 2.42 – 2.36 (m, 1H), 2.20 – 2.07 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 158.5, 140.1, 133.9, 130.9, 127.9, 127.4, 125.6, 123.9, 78.7, 69.0, 30.6, 26.1.
IR: 3080, 3074, 3045, 2962, 2925, 2856, 1618, 1569, 1257, 1055, 966, 763, 675.
HRMS (ESI) m/z calcd for $C_{13}H_{12}ClNO$ $[M+H]^+$: 234.06802, found: 234.06842.

(**2o**) 4-Bromo-1-(tetrahydrofuran-2-yl)isoquinoline (2408961-61-3)[5]

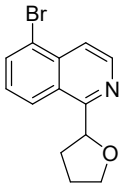


4-bromo-1-(tetrahydrofuran-2-yl)
isoquinoline
Chemical Formula: $C_{13}H_{12}BrNO$
Exact Mass: 277.0102
Molecular Weight: 278.1490

Following the General Procedure A with 4-bromoisoquinoline (41.6 mg, 0.2 mmol), **2o** was obtained as yellow oil (41.2 mg, 74%), R_f = 0.5 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) *δ* 8.67 (s, 1H), 8.34 (d, *J* = 8.4 Hz, 1H), 8.18 (d, *J* = 8.8 Hz, 1H), 7.77 (t, *J* = 7.2 Hz, 1H), 7.65 (t, *J* = 8.0 Hz, 1H), 5.66 (t, *J* = 7.2 Hz, 1H), 4.17 – 4.11 (m, 1H), 4.04 – 3.99 (m, 1H), 2.56 – 2.47 (m, 1H), 2.42 – 2.33 (m, 1H), 2.20 – 2.04 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.1, 143.0, 135.0, 131.1, 128.0, 127.8, 126.6, 125.6, 119.2, 78.6, 69.0, 30.5, 26.0.

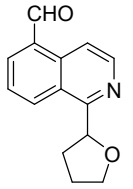
(**2p**) 5-Bromo-1-(tetrahydrofuran-2-yl)isoquinoline (2095358-00-0)[5]



5-bromo-1-(tetrahydrofuran-2-yl) isoquinoline
Chemical Formula: $C_{13}H_{12}BrNO$
Exact Mass: 277.0102
Molecular Weight: 278.1490

Following the General Procedure A with 5-bromoisoquinoline (41.6 mg, 0.2 mmol), **2p** was obtained as colorless oil (31.7 mg, 57%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.59 (d, J = 5.5 Hz, 1H), 8.34 (d, J = 8.4 Hz, 1H), 7.95 (d, J = 6.4 Hz, 2H), 7.44 (t, J = 8.4 Hz, 1H), 5.70 (t, J = 7.2 Hz, 1H), 4.18 – 4.12 (m, 1H), 4.05 – 3.99 (m, 1H), 2.59 – 2.50 (m, 1H), 2.43 – 2.34 (m, 1H), 2.20 – 2.06 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 160.0, 142.7, 135.6, 133.6, 127.7, 127.4, 125.1, 122.2, 119.4, 79.0, 69.0, 30.6, 26.0.

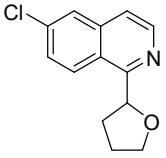
(**2q**) 4-(Tetrahydrofuran-2-yl)isoquinoline-5-carbaldehyde



1-(tetrahydrofuran-2-yl)isoquinoline -5-carbaldehyde
Chemical Formula: $C_{14}H_{13}NO_2$
Exact Mass: 227.0946
Molecular Weight: 227.2630

Following the General Procedure A with isoquinoline-5-carbaldehyde (31.4 mg, 0.2 mmol), **2q** was obtained as colorless oil (11.8 mg, 26%), R_f = 0.2 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 10.39 (s, 1H), 8.97 (d, J = 6,0 Hz, 1H), 8.72 – 8.66 (m, 2H), 8,19 (d, J = 7.2 Hz, 1H), 7.78 (t, J = 8.0 Hz, 1H), 5.71 (t, J = 7,2 Hz, 1H), 4.18 – 4,12 (m, 1H), 4.06 – 4.00 (m, 1H), 2.67 – 2.58 (m, 1H), 2.42 – 2.36 (m, 1H), 2.23 – 2.09 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 192.6, 159.8, 144.6, 139.1, 134.2, 132.5, 130.8, 126.8, 126.1, 117.2, 79.4, 69.0, 30.2, 26.1.
Melting point (°C): 155.6 – 108.0 °C.
IR: 2989, 2987, 2964, 2879, 2750, 1678, 1564, 1225, 1180, 1057, 852, 769, 660.
HRMS (ESI) m/z calcd for $C_{14}H_{13}N_2O$ $[M+H]^+$: 228.10191, found: 228.10199.

(**2r**) 6-Chloro-1-(tetrahydrofuran-2-yl)isoquinoline (2095357-99-4)[5]

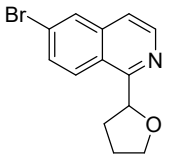


6-chloro-1-(tetrahydrofuran-2-yl) isoquinoline
Chemical Formula: $C_{13}H_{12}ClNO$
Exact Mass: 233.0607
Molecular Weight: 233.6950

Following the General Procedure A with 6-chloroisoquinoline (32.7 mg, 0.2 mmol), **2r** was obtained as yellow oil (15.0 mg, 32%), R_f = 0.4 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (d, J = 5.6 Hz, 1H), 8.32 (d, J = 8.8 Hz, 1H), 7.81 (s, 1H), 7.54 (d, J = 9.2 Hz, 1H), 7.50 (d, J = 5.6 Hz, 1H), 5.65 (t, J = 6.8 Hz, 1H), 4.19

– 4.13 (m, 1H), 4.05 – 4.00 (m, 1H), 2.57 – 2.48 (m, 1H), 2.43 – 2.35 (m, 1H), 2.22 – 2.07 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.7, 142.4, 137.4, 136.2, 128.1, 127.3, 126.0, 124.8, 119.7, 79.2, 69.0, 30.6, 26.1.

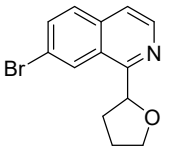
(**2s**) 6-Bromo-1-(tetrahydrofuran-2-yl)isoquinoline (2095357-98-3)[6]



6-bromo-1-(tetrahydrofuran-2-yl) isoquinoline
Chemical Formula: $C_{13}H_{12}BrNO$
Exact Mass: 277.0102
Molecular Weight: 278.1490

Following the General Procedure A with 6-bromoisoquinoline (41.6 mg, 0.2 mmol), **2s** was obtained as white solid (39.5 mg, 71%), R_f = 0.2 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (d, J = 5.6 Hz, 1H), 8.23 (d, J = 9.2 Hz, 1H), 7.97 (d, J = 1.2 Hz, 1H), 7.67 – 7.64 (m, 1H), 7.47 (d, J = 6.0 Hz, 1H), 5.63 (t, J = 7.2 Hz, 1H), 4.17 – 4.11(m, 1H), 4.04 – 3.98 (m, 1H), 2.56 – 2.48 (m, 1H), 2.41 – 2.33 (m, 1H), 2.19 – 2.06 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.8, 142.4, 137.7, 130.6, 129.3, 127.2, 125.0, 124.6, 119.4, 79.1, 69.0, 30.5, 26.0.

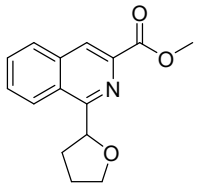
(**2t**) 7-Bromo-1-(tetrahydrofuran-2-yl)isoquinoline (2095358-02-2)[6]



7-bromo-1-(tetrahydrofuran-2-yl) isoquinoline
Chemical Formula: $C_{13}H_{12}BrNO$
Exact Mass: 277.0102
Molecular Weight: 278.1490

Following the General Procedure A with 7-bromoisoquinoline (41.6 mg, 0.2 mmol), **2t** was obtained as white solid (31.2 mg, 56%), R_f = 0.3 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 853 – 8.50 (m, 2H), 7.75 – 7.68 (m, 2H), 7.54 (d, J = 6.0 Hz, 1H), 5.60 (t, J = 7.2 Hz, 1H), 4.18 – 4.13 (m, 1H), 4.06 – 4.00 (m, 1H), 2.58 – 2.50 (m, 1H), 2.42 – 2.34 (m, 1H), 2.22 – 2.07 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 141.7, 134.9, 133.3, 128.8, 127.8, 127.5, 120.9, 120.1, 79.0, 68.9, 30.4, 26.0.

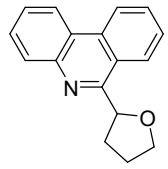
(**2u**) Methyl 1-(tetrahydrofuran-2-yl)isoquinoline-3-carboxylate (2095358-05-5)[6]



methyl 1-(tetrahydrofuran-2-yl) isoquinoline-3-carboxylate
Chemical Formula: $C_{15}H_{15}NO_3$
Exact Mass: 257.1052
Molecular Weight: 257.2890

Following the General Procedure A with methyl isoquinoline-3-carboxylate (37.4 kmg, 0.2 mmol), **2u** was obtained as white solid (27.3 mg, 53%), R_f = 0.3 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 – 8.50 (m, 2H), 7.98 – 7.95 (m, 1H), 7.77 – 7.71 (m, 2H), 5.68 (t, J = 7.2 Hz, 1H), 4.17 (dd, J = 14.8, 7.6 Hz, 1H), 4.06 – 4.00 (m, 4H), 2.74 – 2.65 (m, 1H), 2.47 – 2.38 (m, 1H), 2.27 – 2.08 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 160.0, 139.9, 136.4, 130.6, 129.3, 128.8, 128.1, 126.1, 124.2, 80.4, 69.0, 52.7, 30.3, 26.1.

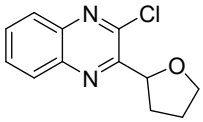
(**2v**) 6-(Tetrahydrofuran-2-yl)phenanthridine (1588454-61-8)[5]



6-(tetrahydrofuran-2-yl) phenanthridine
Chemical Formula: $C_{17}H_{15}NO$
Exact Mass: 249.1154
Molecular Weight: 249.3130

Following the General Procedure A with phenanthridine (35.8 mg, 0.2 mmol), **2v** was obtained as colorless oil (30.4 mg, 61%), R_f = 0.6 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.63 (d, J = 8.4 Hz, 1H), 8.54 (d, J = 8.0 Hz, 1H), 8.45 (d, J = 8.4 Hz, 1H), 8.21 (d, J = 8.0 Hz, 1H), 7.82 (t, J = 7.2 Hz, 1H), 7.74 – 7.62 (m, 3H), 5.78 (t, J = 6.8 Hz, 1H), 4.24 – 4.19 (m, 1H), 4.10 – 4.05 (m, 1H), 2.79 – 2.71 (m, 1H), 2.47 – 2.38 (m, 1H), 2.23 – 2.18 (m, 1H), 2.16 – 2.10 (m, 1H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.2, 143.1, 133.2, 130.32, 130.26, 128.4, 127.1, 126.8, 126.4, 124.7, 124.0, 122.3, 121.8, 79.5, 69.0, 30.0, 25.9.

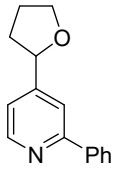
(**2w**) 2-Chloro-3-(tetrahydrofuran-2-yl)quinoxaline (2770705-43-4)[5]



Chemical Formula: $C_{12}H_{11}ClN_2O$
Exact Mass: 234.0560
Molecular Weight: 234.6830

Following the General Procedure A with 2-chloroquinoxaline (32.9 mg, 0.2 mmol), **2w** was obtained as colorless oil (21.6 mg, 46%), R_f = 0.2 (petroleum ether/ethyl acetate = 6:1).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 – 8.13 (m, 1H), 8.00 – 7.98 (m, 1H), 7.76 – 7.73 (m, 2H), 5.55 (t, J = 6.0 Hz, 1H), 4.29 – 4.23 (m, 1H), 4.08 – 4.03 (m, 1H), 2.53 – 2.48 (m, 1H), 2.27 – 2.22 (m, 1H), 2.18 – 2.06 (m, 2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 154.5, 146.0, 141.3, 140.6, 130.6, 130.1, 129.3, 128.0, 78.0, 69.4, 30.9, 25.7.

(**2x**) 2-Phenyl-4-(tetrahydrofuran-2-yl)pyridine (1795742-55-0)[7]



Chemical Formula: $C_{15}H_{15}NO$
Exact Mass: 225.1154
Molecular Weight: 225.2910

Following the General Procedure A with 2-phenylpyridine (31.0 mg, 0.2 mmol), **2x** was obtained as yellow oil (18.5 mg, 41%), R_f = 0.3 (petroleum ether/ethyl acetate = 4:1).
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.63 (d, J = 5.2 Hz, 1H), 8.00 (d, J = 6.8 Hz, 2H), 7.70 (s, 1H), 7.49 – 7.39 (m, 3H), 7.19 (d, J = 4.4 Hz, 1H), 4.97 (t, J = 7.2 Hz, 1H), 4.15 – 4.10 (m, 1H), 4.02–3.96 (m, 1H), 2.44 –2.38 (m, 1H), 2.06–1.98 (m, 2H), 1.84–1.79 (m, 1H).
^{13}C NMR (101 MHz, $CDCl_3$): δ 157.5, 153.7, 149.5, 139.3, 128.93, 128.9, 127.0, 119.0, 117.3, 79.2, 69.0, 34.3, 25.8.

5 References

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2. C. Y. Huang, J. Li, W. Liu and C. J. Li, *Chem. Sci*., 2019, **10** , 5018–5024.
3. X. Li, C. Liu, S. Guo, W. Wang and Y. Zhang, *Eur. J. Org. Chem.*, 2021, 411–421.
4. S. Wang, Y. Fan, H. Zhao, J. Wang, S. Zhang and W. Wang, *Synlett*, 2019, **30** 2096–2100.
5. L. Li, X. Song, M. F. Qi and B. Sun, *Tetrahedron*., 2022, **99**, 153846.
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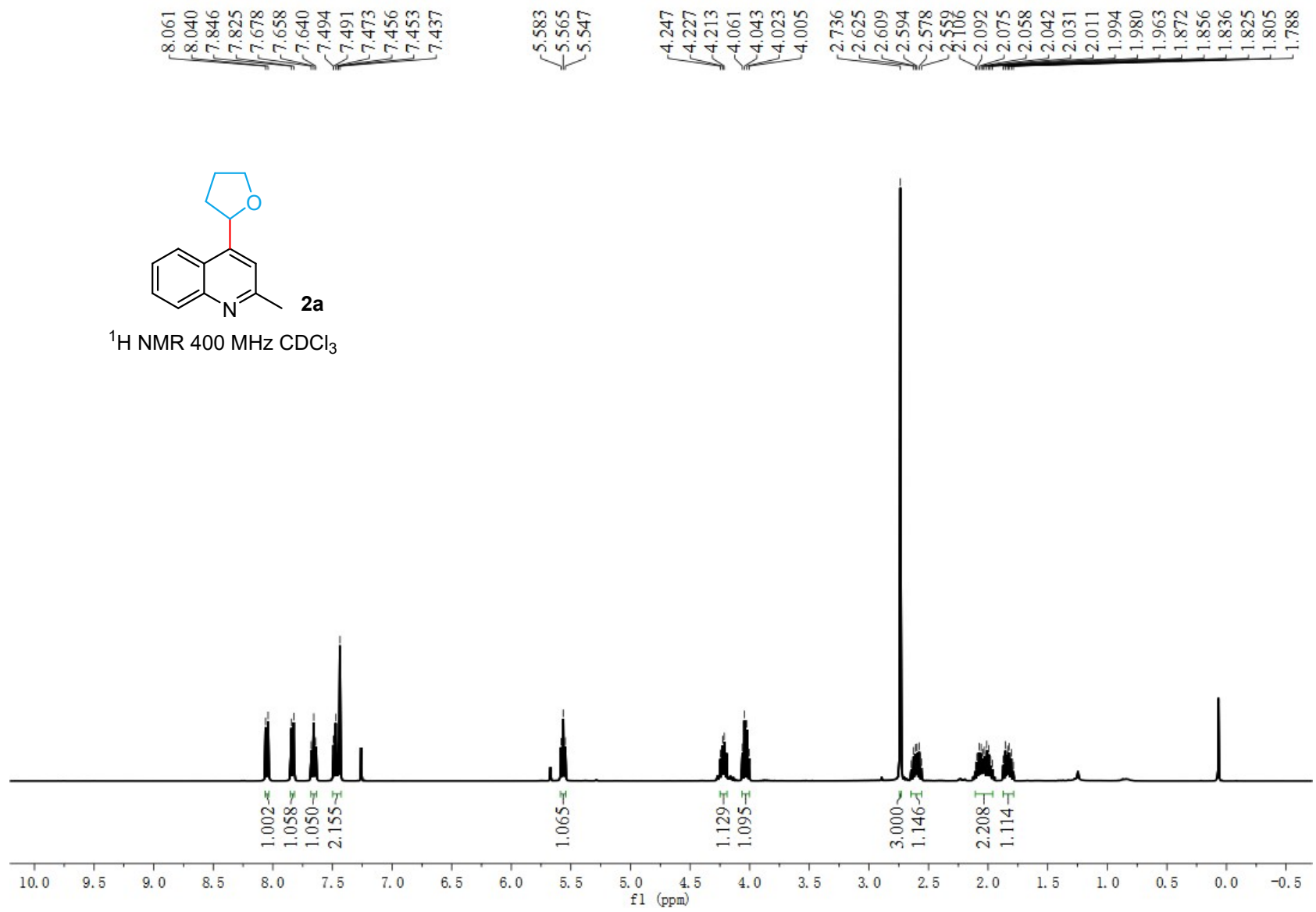
7. Z. Zhou, Y. Wu, P. Yang, S. Deng, Q. Zhang and D. Li, *ChemistrySelect*, 2021, **6**, 2770 –2773.

6 Copies of NMR spectra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1.963
1.872
1.856
1.836
1.825
1.805
1.788
O
N
2a
1H NMR 400 MHz CDCl3
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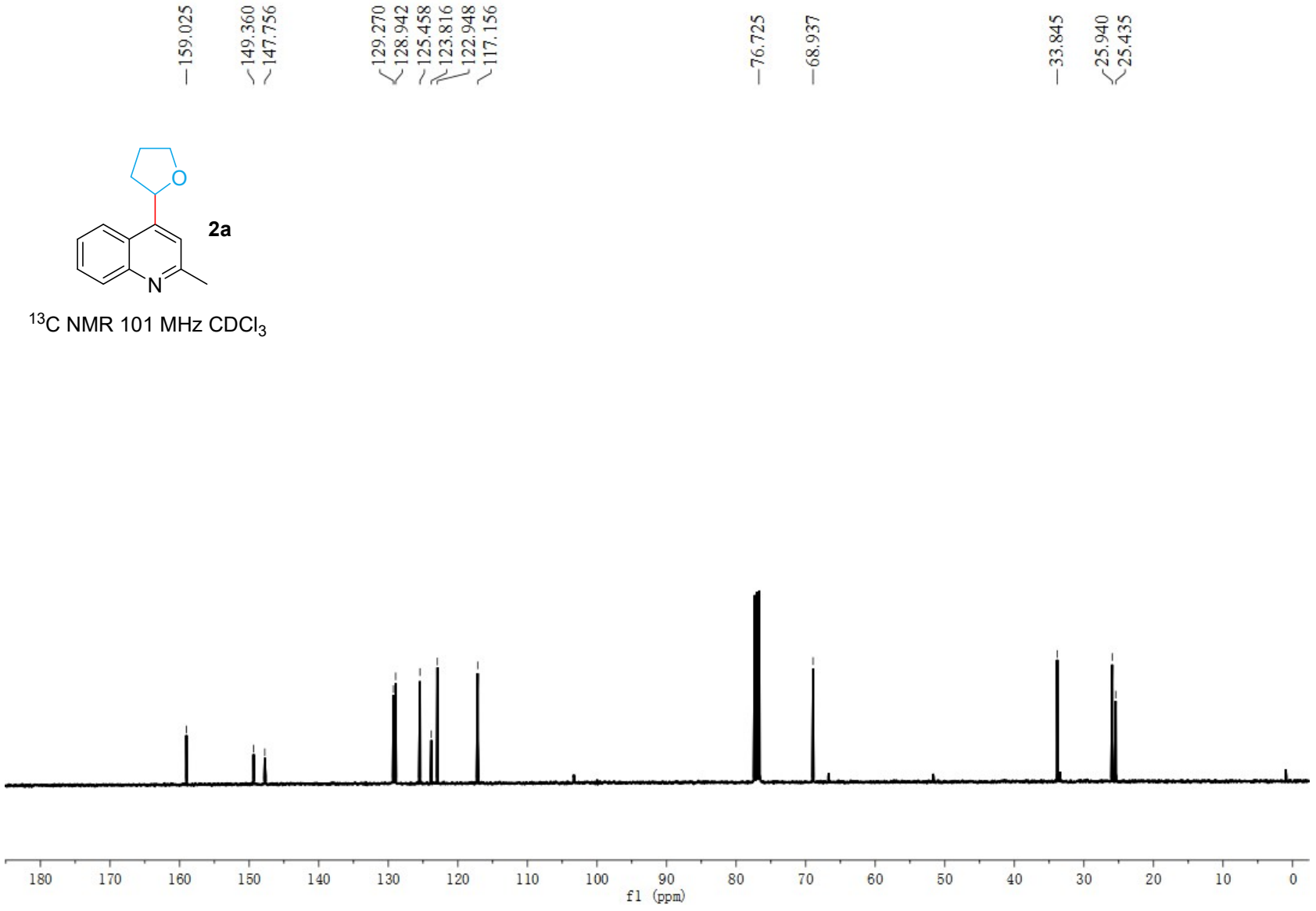
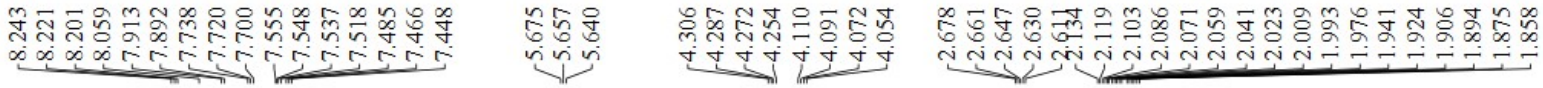
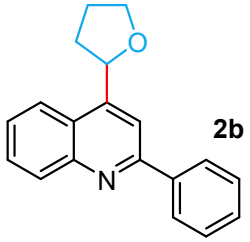
1.058
1.050
2.155
1.065
1.129
1.095
3.000
1.146
2.208
1.114
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)



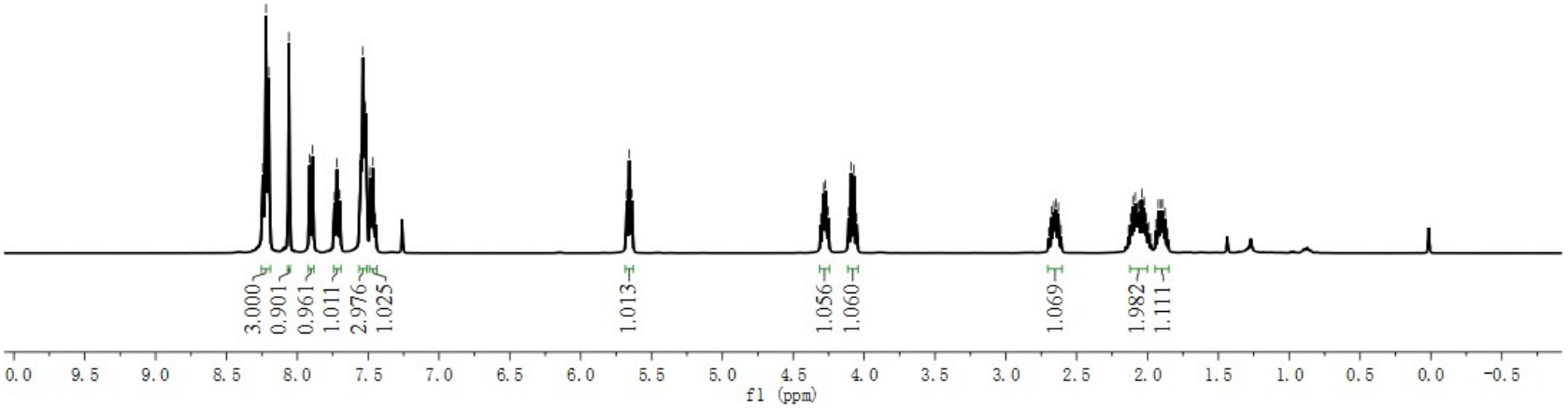
^{13}C NMR 101 MHz $CDCl_3$

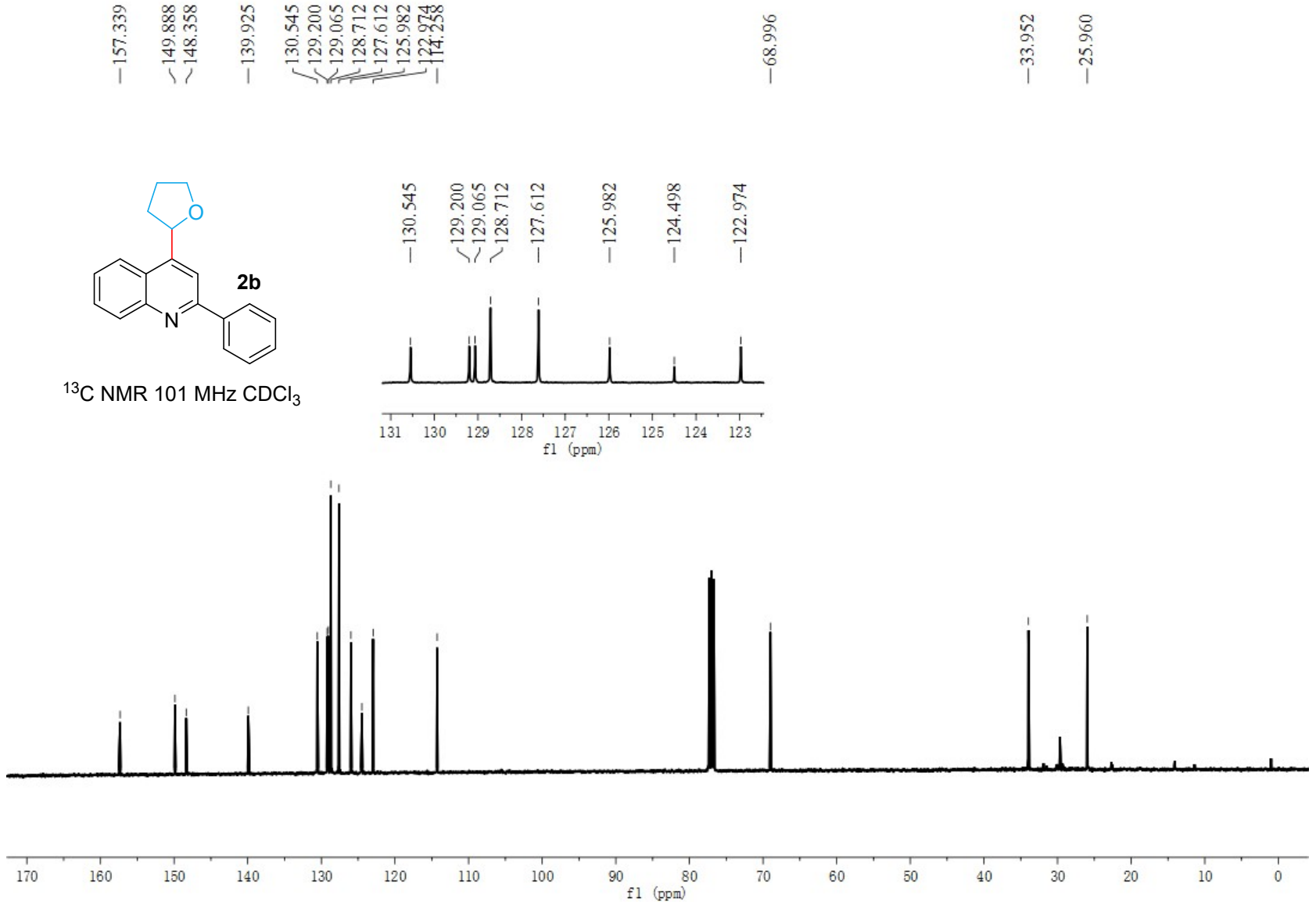




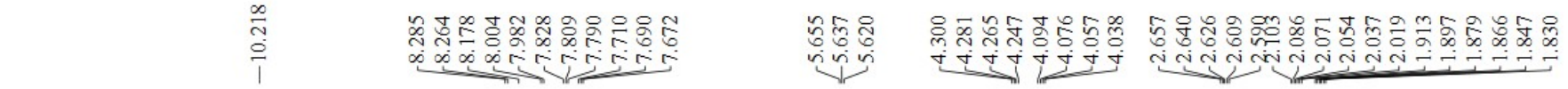
2b

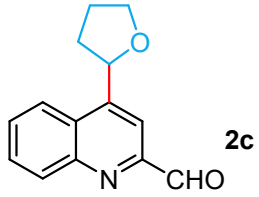
^{1}H NMR 400 MHz $CDCl_3$





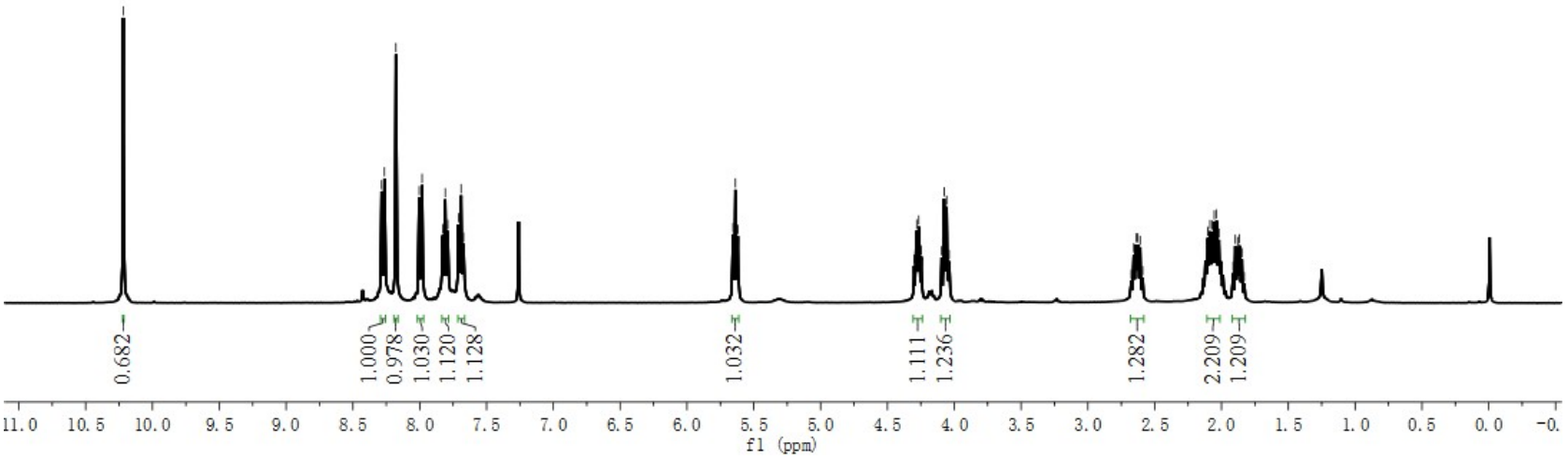
^{13}C NMR 101 MHz $CDCl_3$

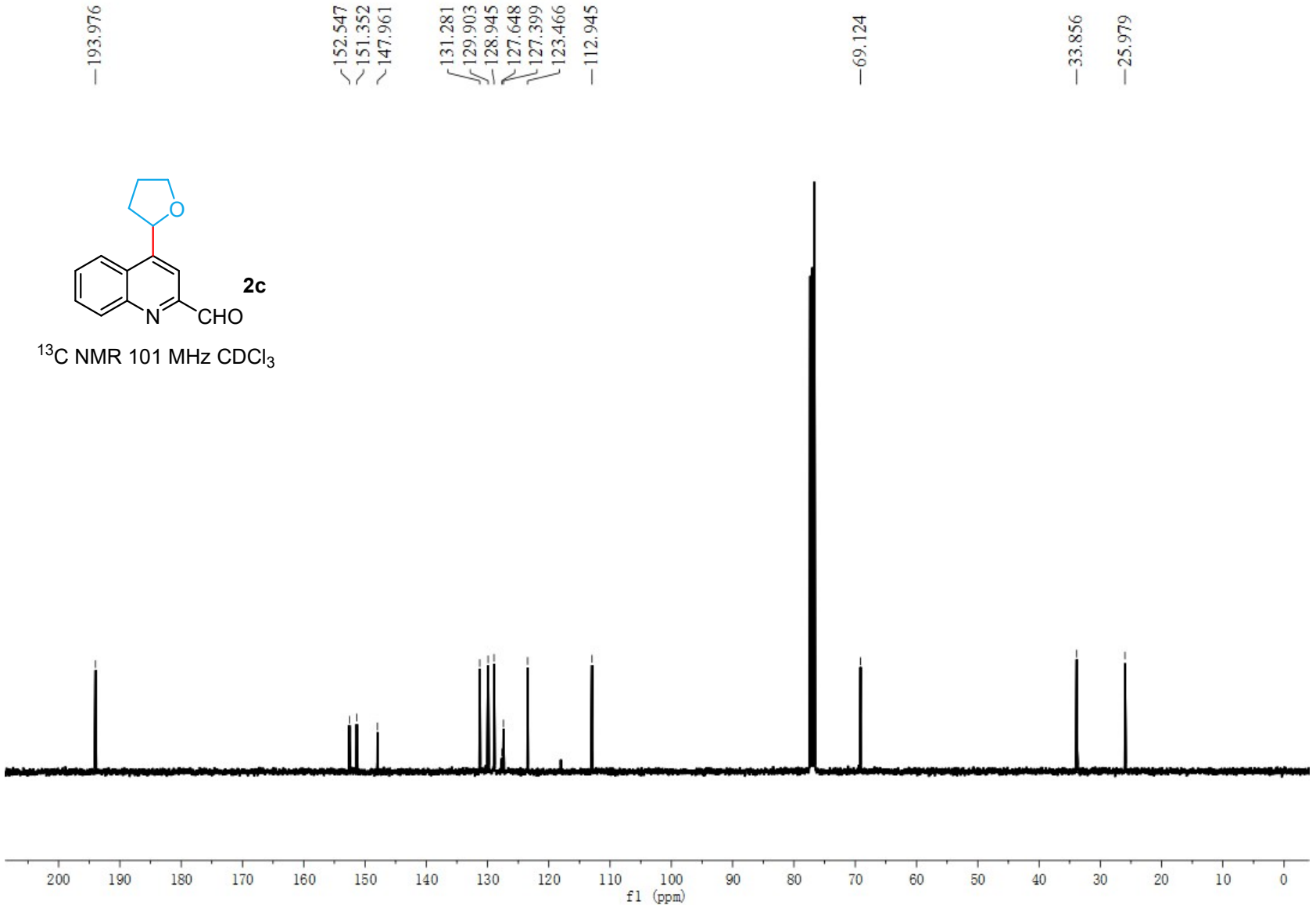


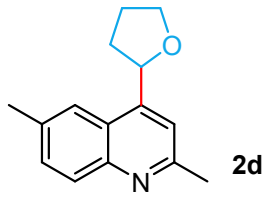


2c

^{1}H NMR 400 MHz $CDCl_3$

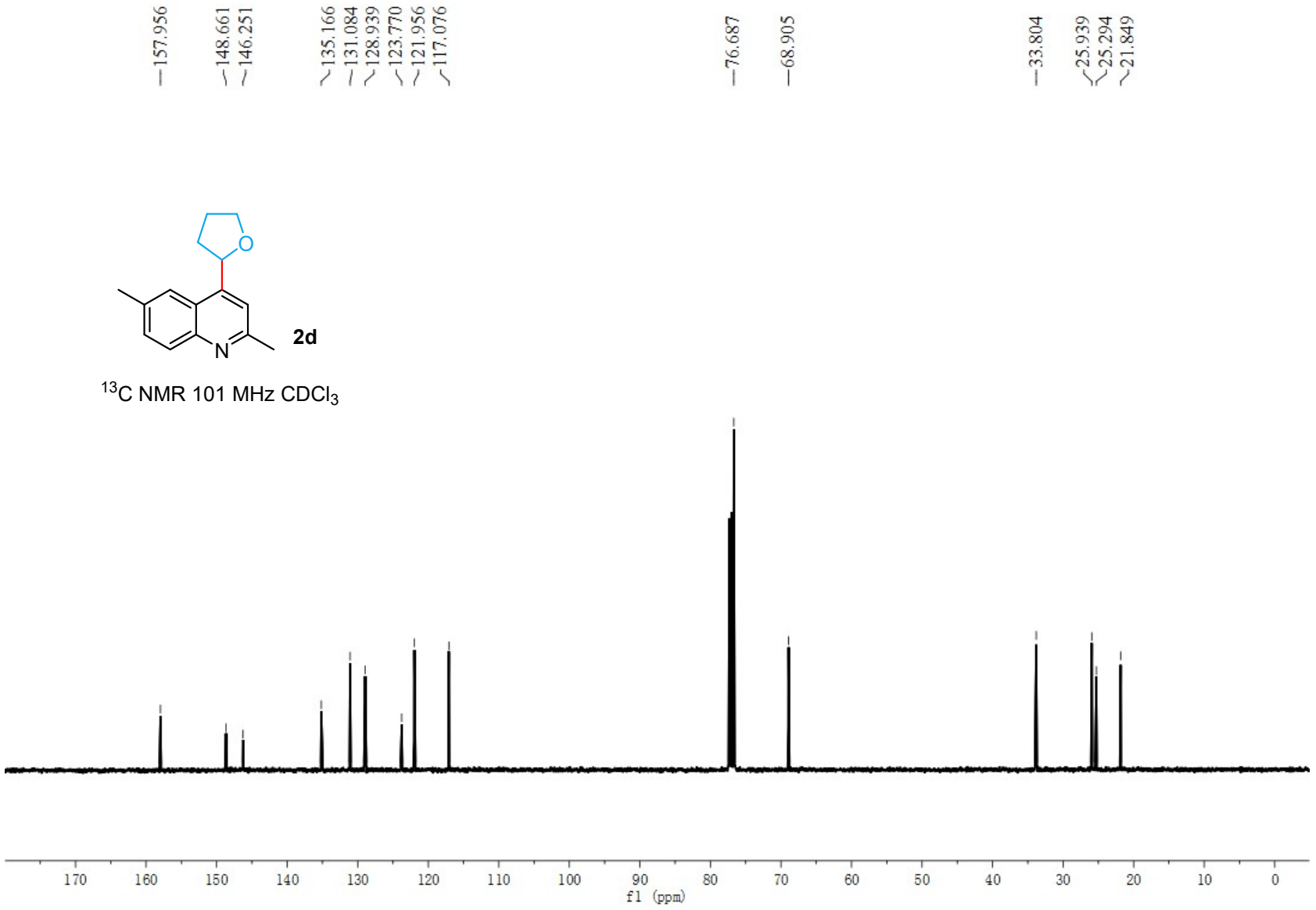


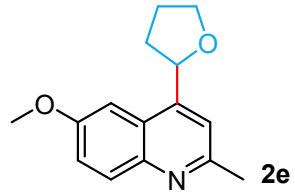

193.976
152.547
151.352
147.961
131.281
129.903
128.945
127.648
127.399
123.466
112.945
69.124
33.856
25.979
O
N
CHO
2c
^{13}C NMR 101 MHz $CDCl_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



2d

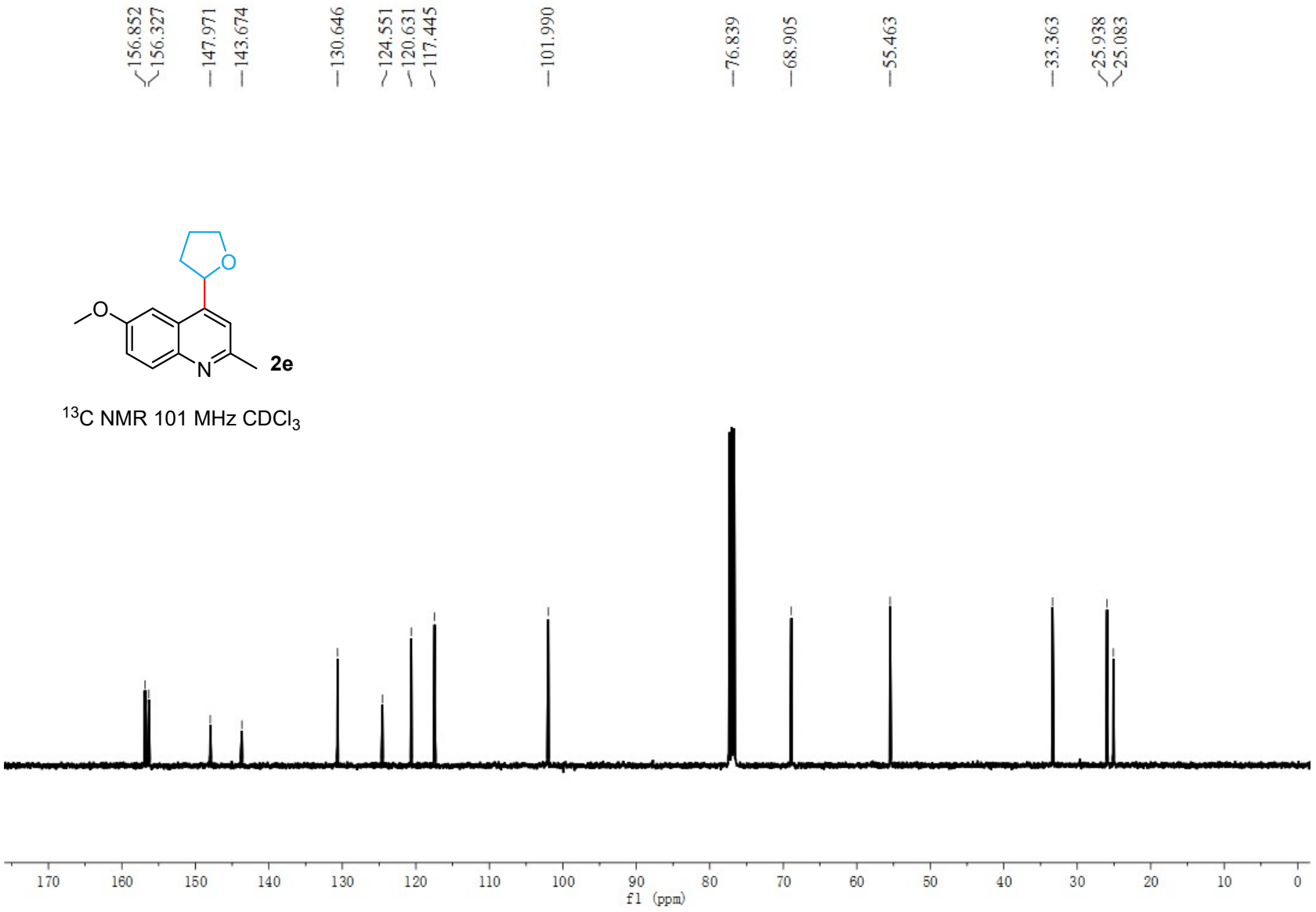
^{1}H NMR 400 MHz $CDCl_3$

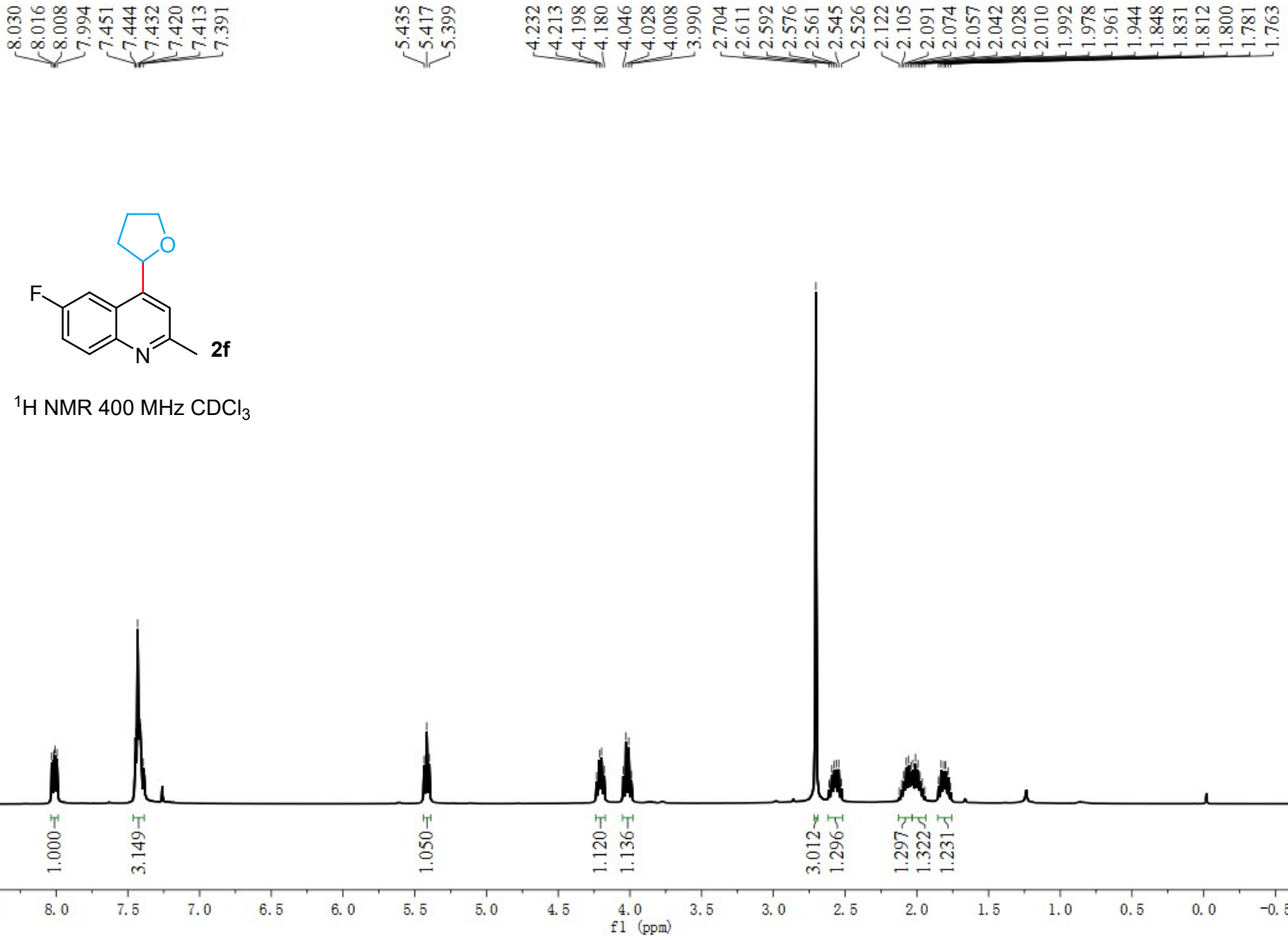

157.956
148.661
146.251
135.166
131.084
128.939
123.770
121.956
117.076
76.687
68.905
33.804
25.939
25.294
21.849
O
N
2d
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



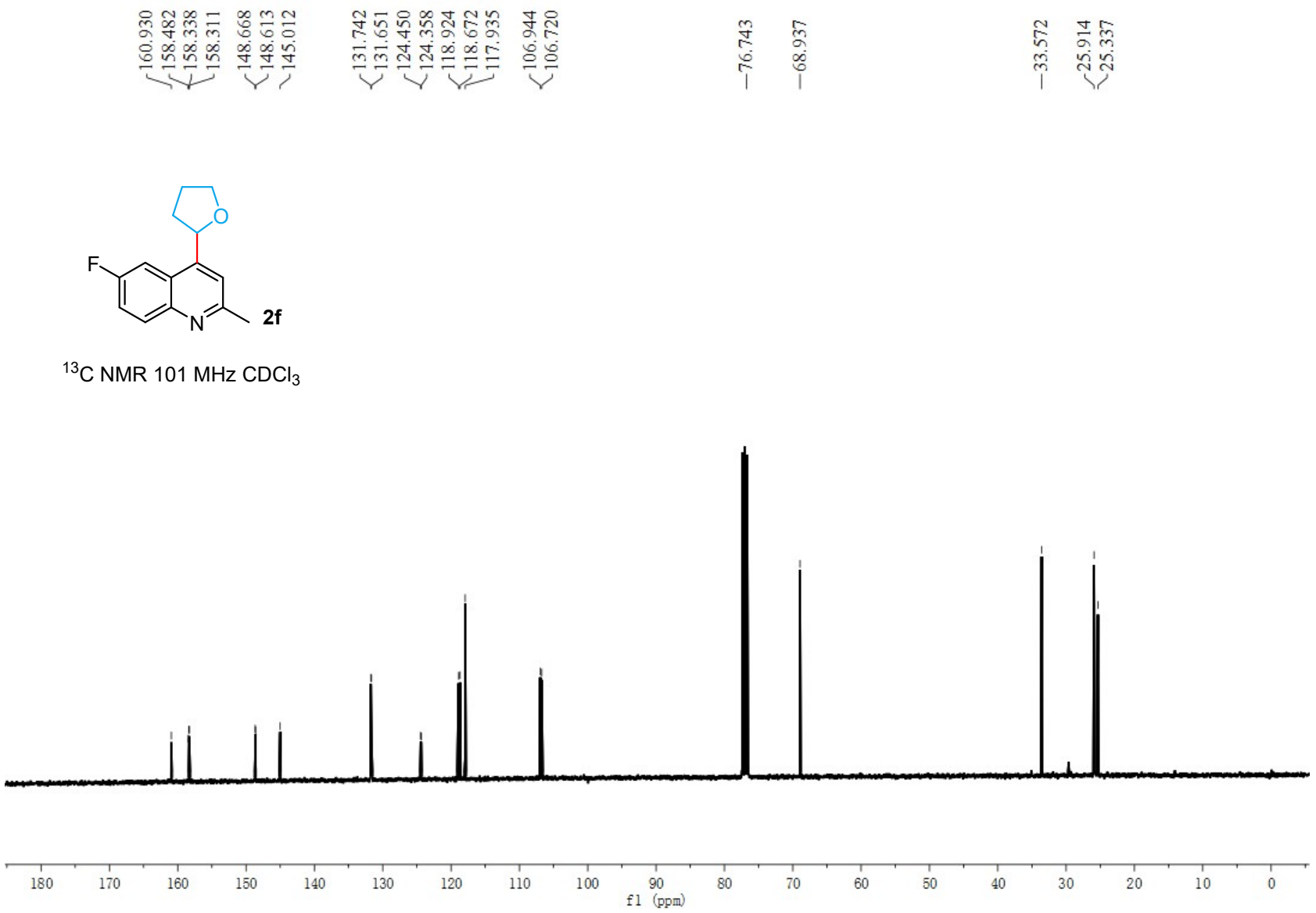
2e

^{1}H NMR 400 MHz $CDCl_3$

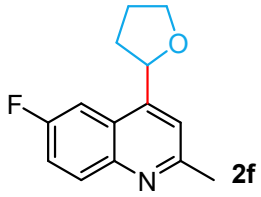

156.852
156.327
147.971
143.674
130.646
124.551
120.631
117.445
101.990
76.839
68.905
55.463
33.363
25.938
25.083
O
O
N
2e
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



^{1}H NMR 400 MHz $CDCl_3$

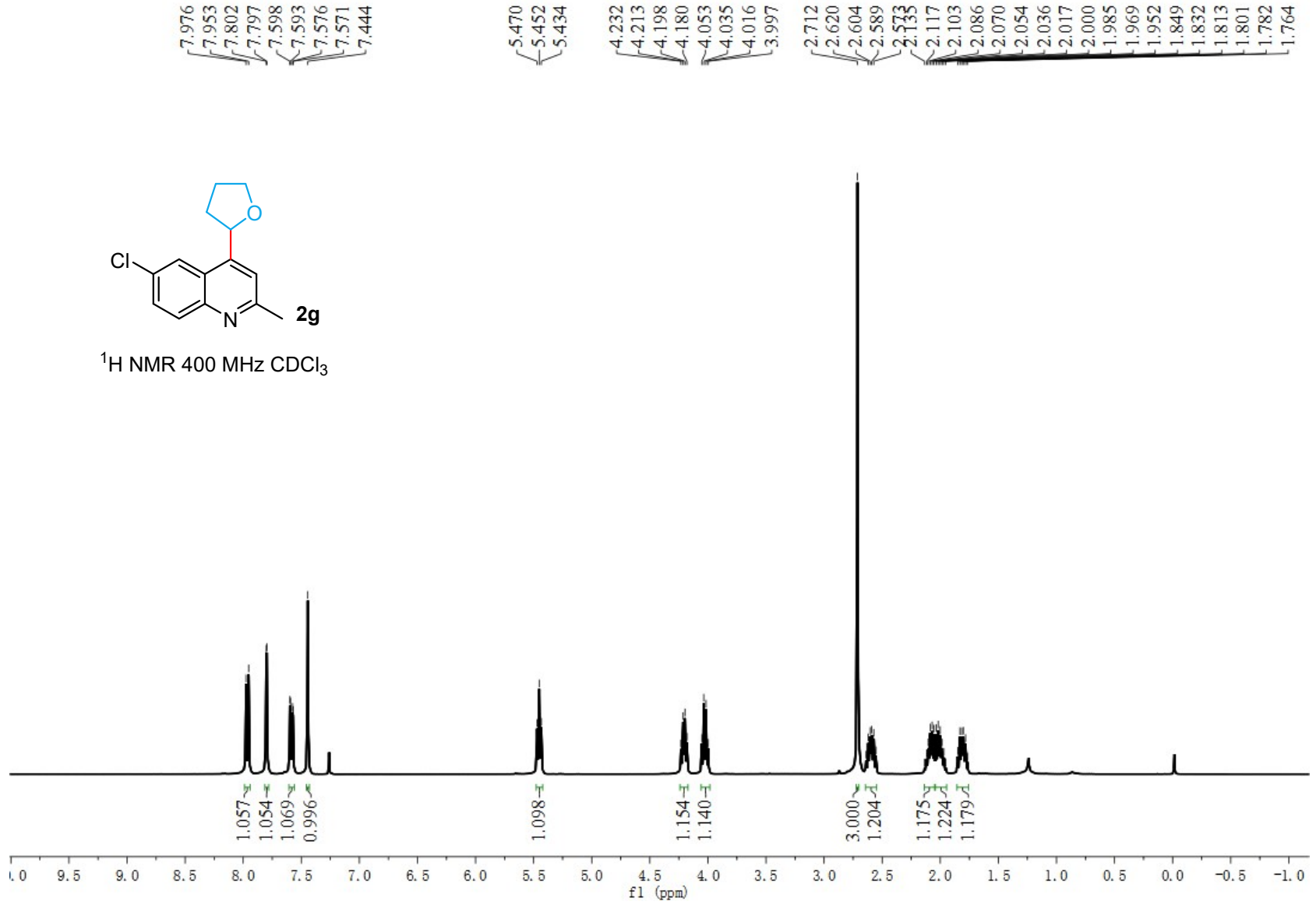


^{13}C NMR 101 MHz $CDCl_3$

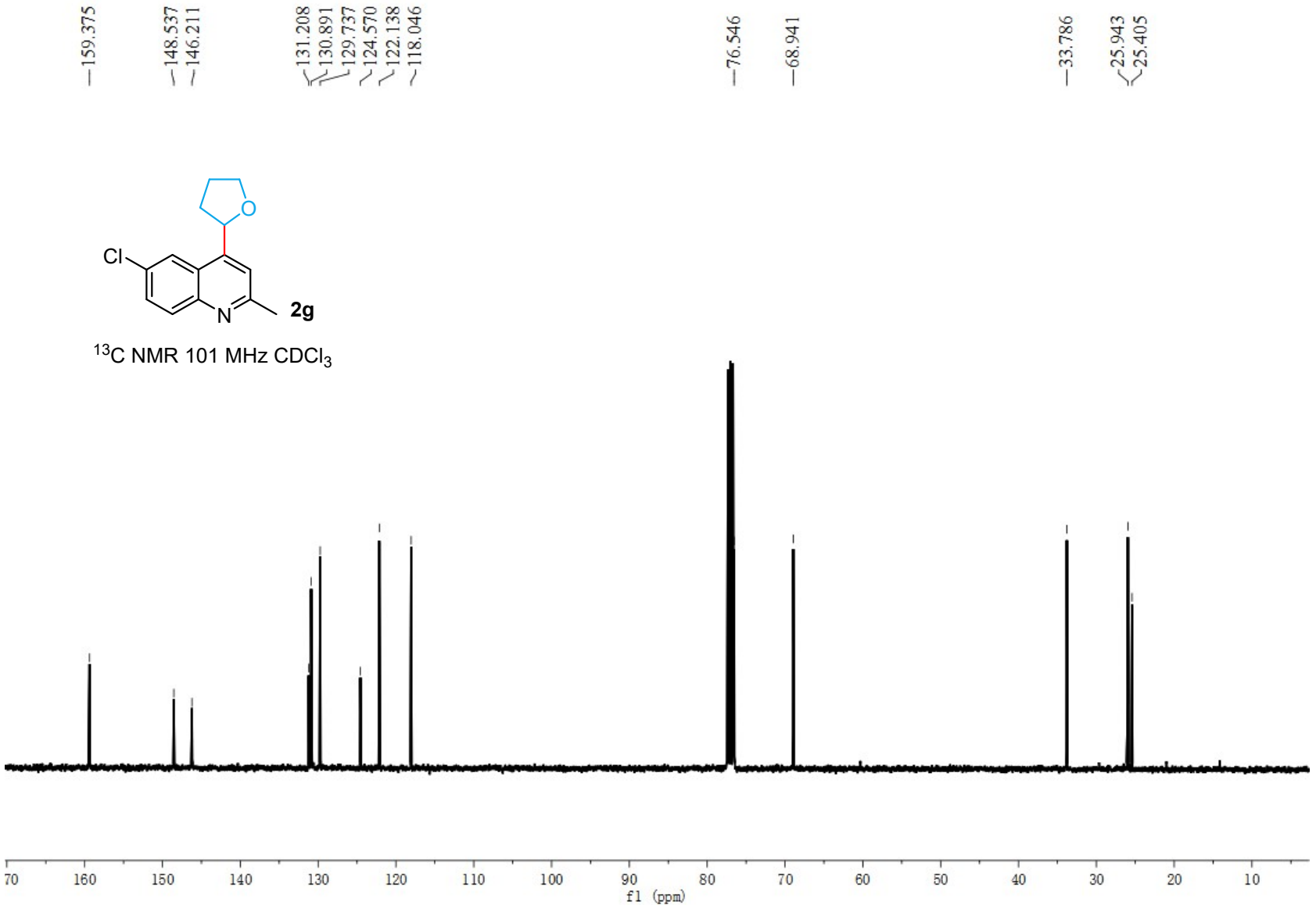


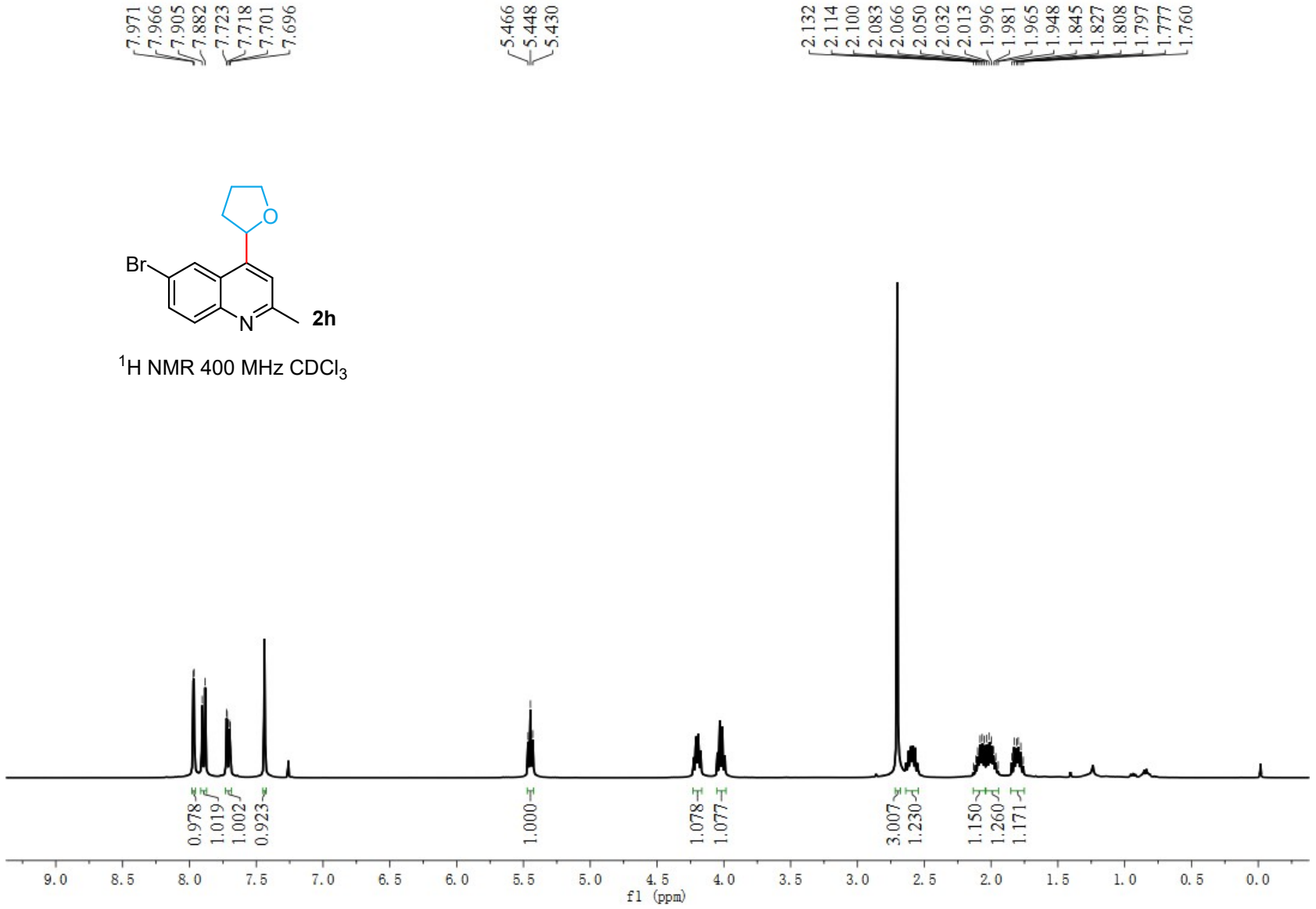
2f

^{19}F NMR 376 MHz $CDCl_3$

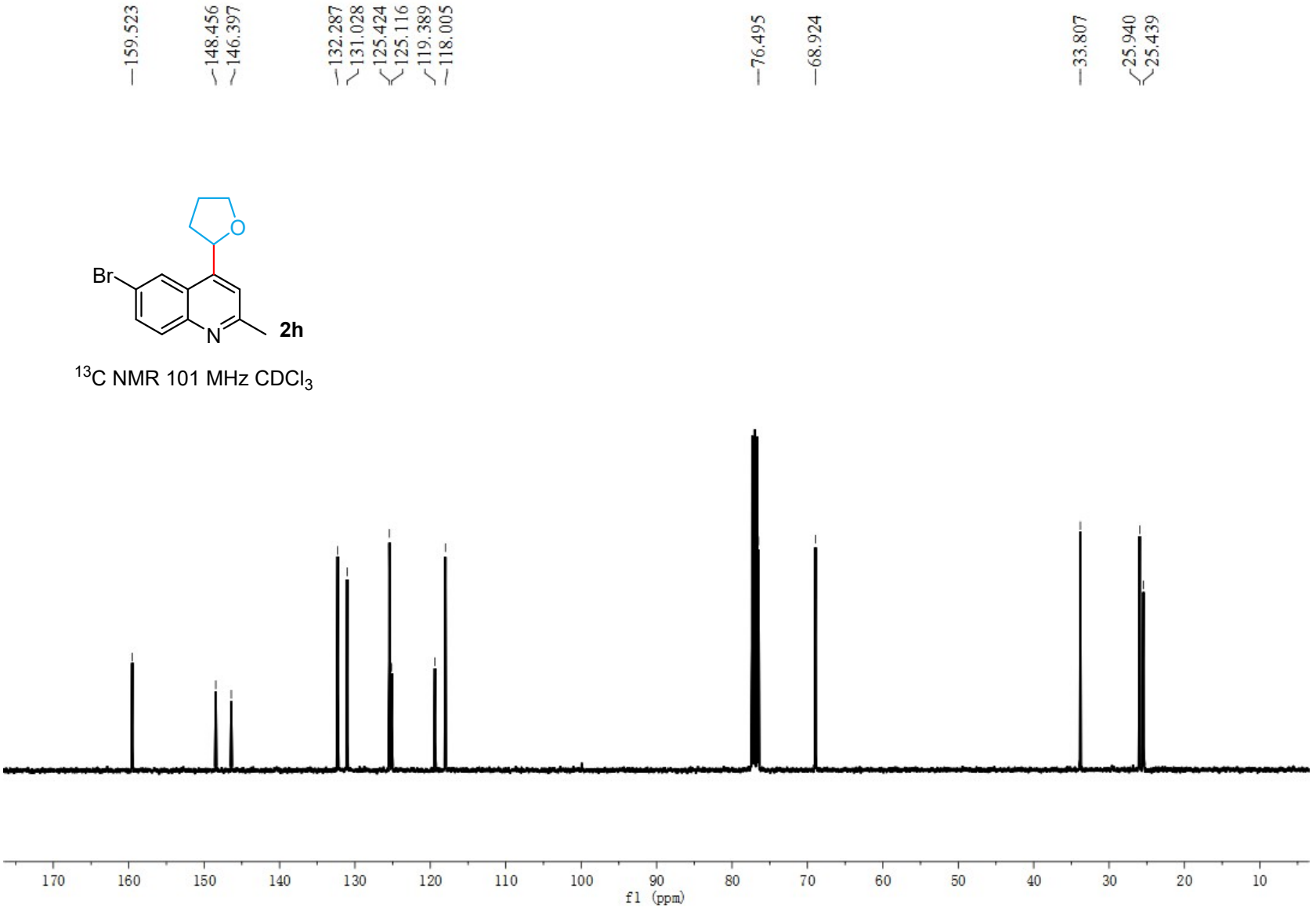


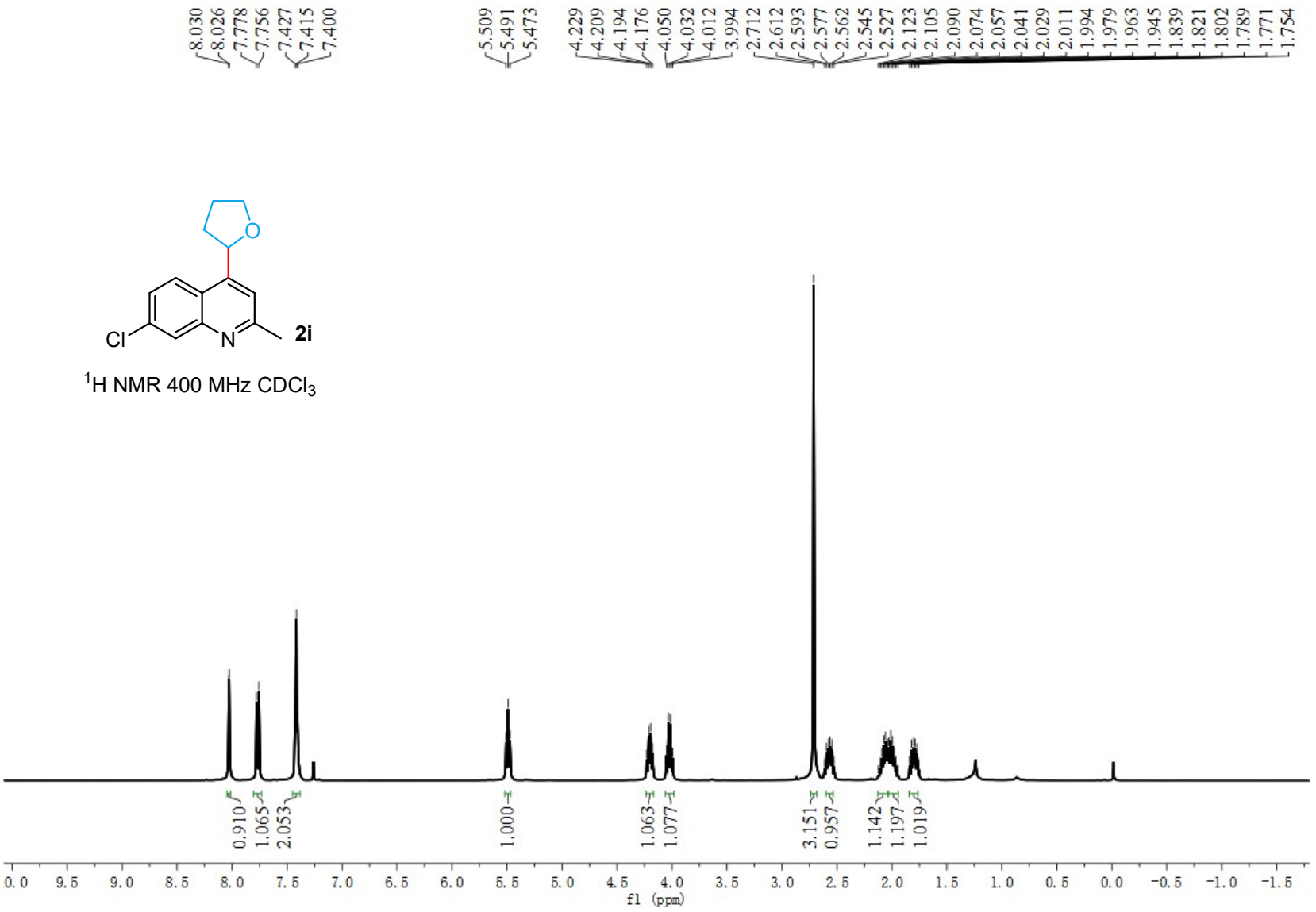
^{1}H NMR 400 MHz $CDCl_3$

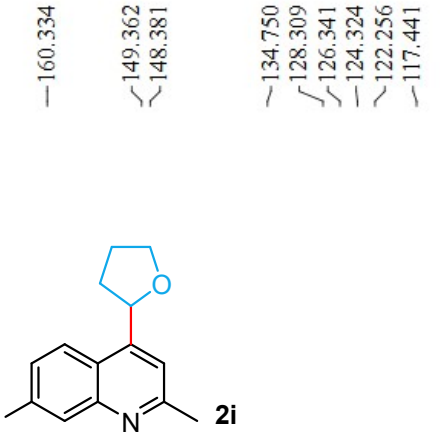

159.375
148.537
146.211
131.208
130.891
129.737
124.570
122.138
118.046
76.546
68.941
33.786
25.943
25.405
Cl
O
N
2g
^{13}C NMR 101 MHz $CDCl_3$
70
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)



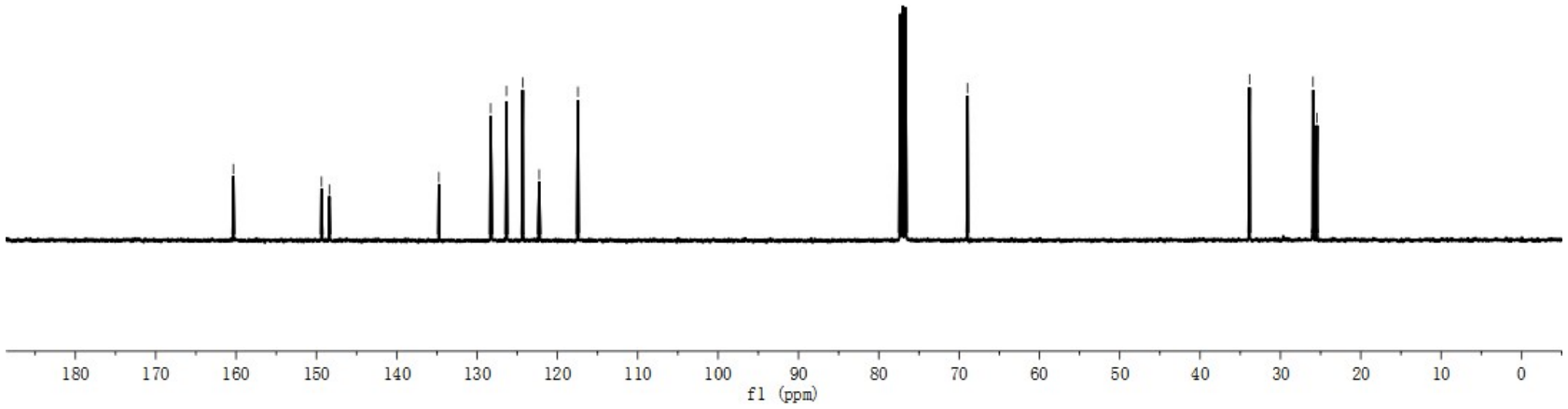
^{1}H NMR 400 MHz $CDCl_3$

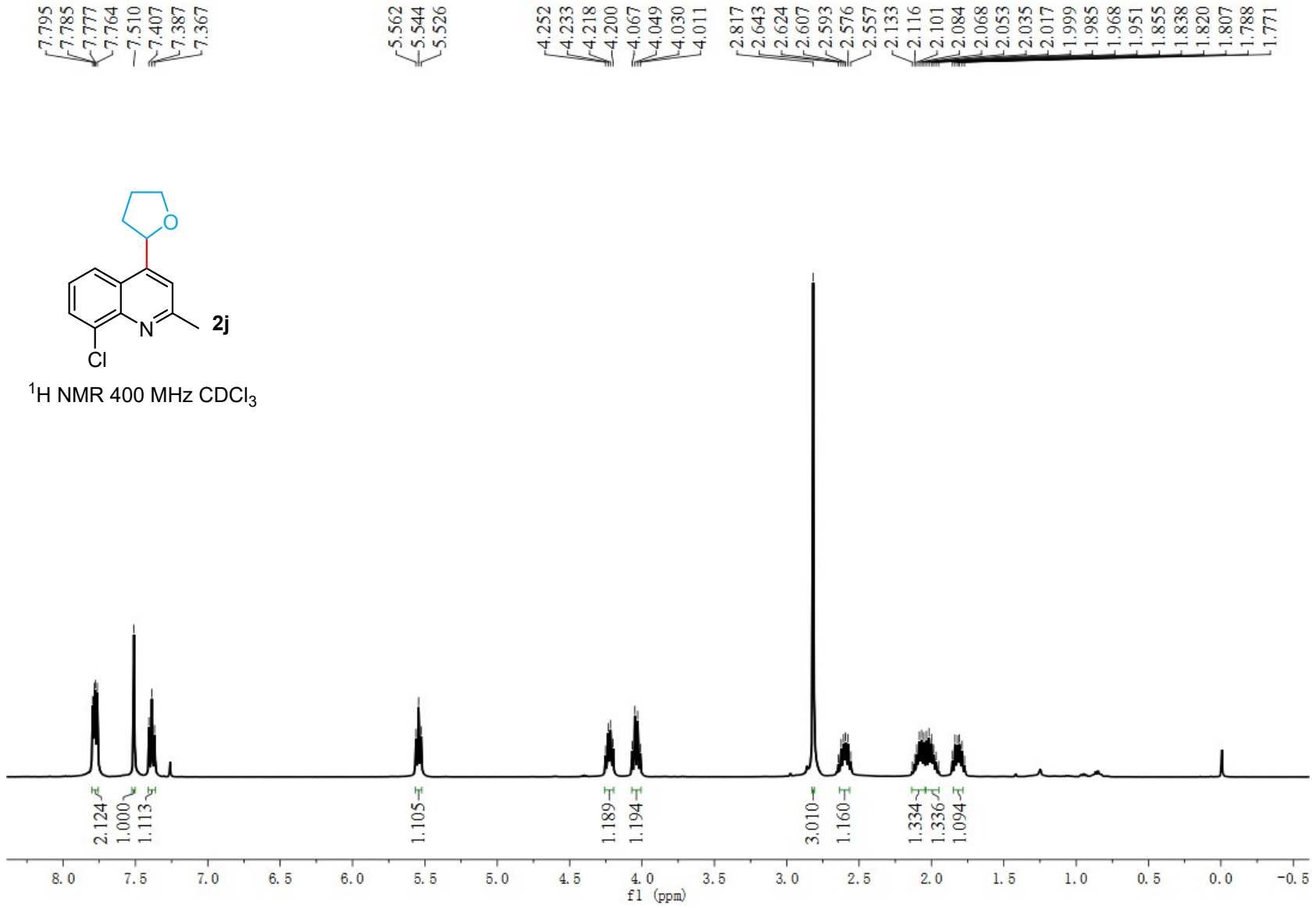

159.523
148.456
146.397
132.287
131.028
125.424
125.116
119.389
118.005
76.495
68.924
33.807
25.940
25.439
Br
O
N
2h
13C NMR 101 MHz CDCl3
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


8.030
8.026
7.778
7.756
7.427
7.415
7.400
5.509
5.491
5.473
4.229
4.209
4.194
4.176
4.050
4.032
4.012
3.994
2.712
2.612
2.593
2.577
2.562
2.545
2.527
2.123
2.105
2.090
2.074
2.057
2.041
2.029
2.011
1.994
1.979
1.963
1.945
1.839
1.821
1.802
1.789
1.771
1.754
O
Cl
N
2i
1H NMR 400 MHz CDCl3
0.910
1.065
2.053
1.000
1.063
1.077
3.151
0.957
1.142
1.197
1.019
f1 (ppm)

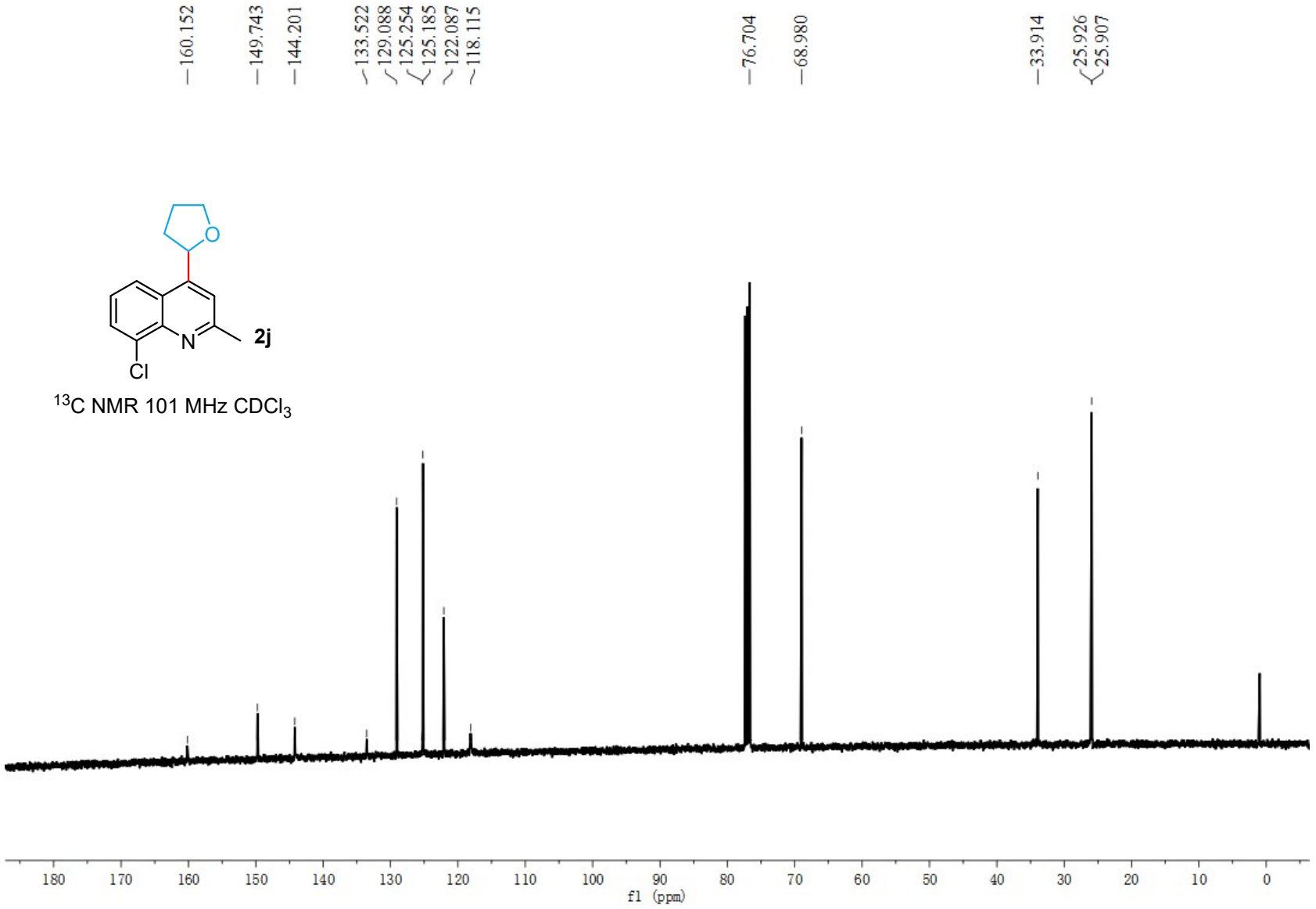


^{13}C NMR 101 MHz $CDCl_3$

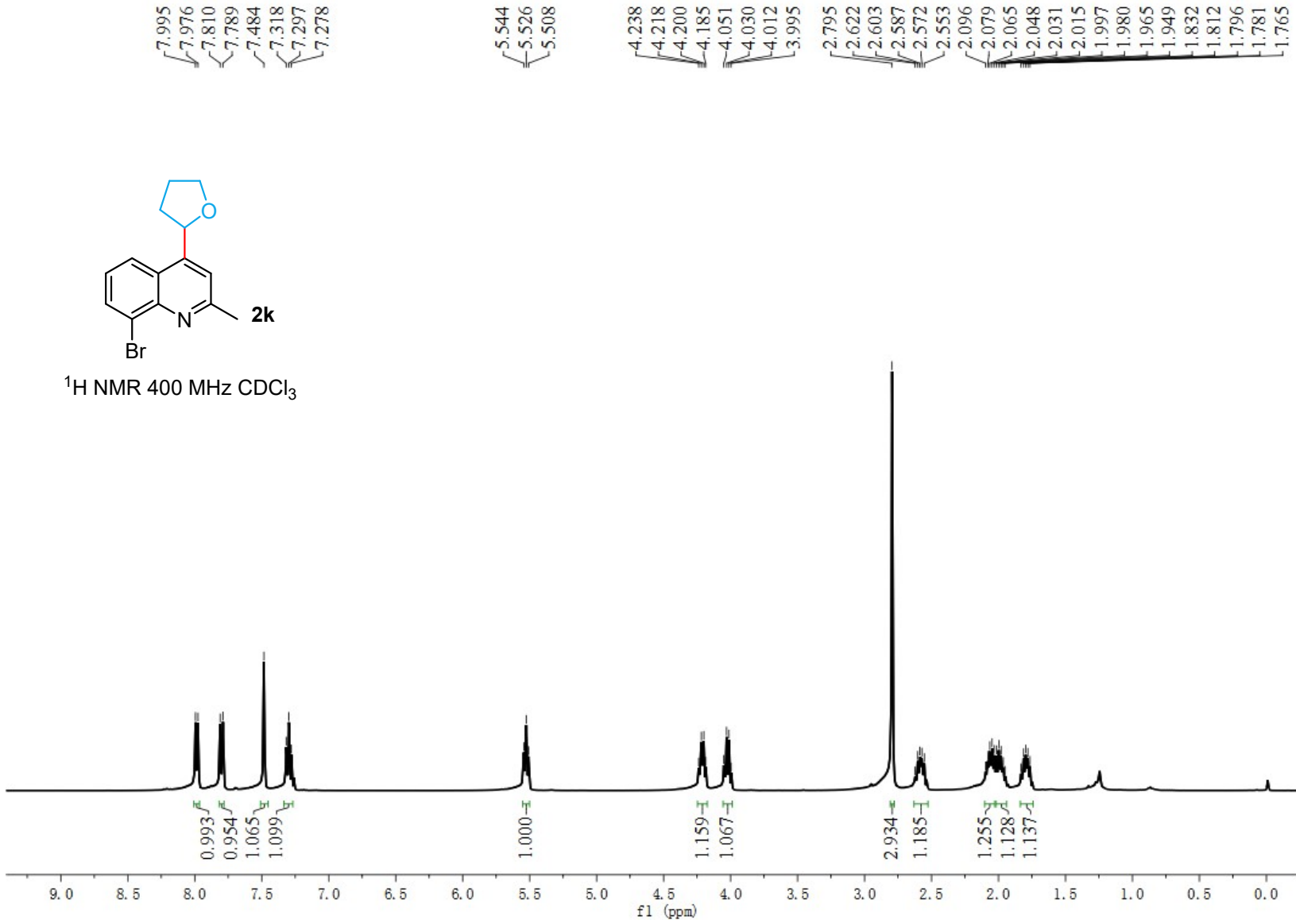




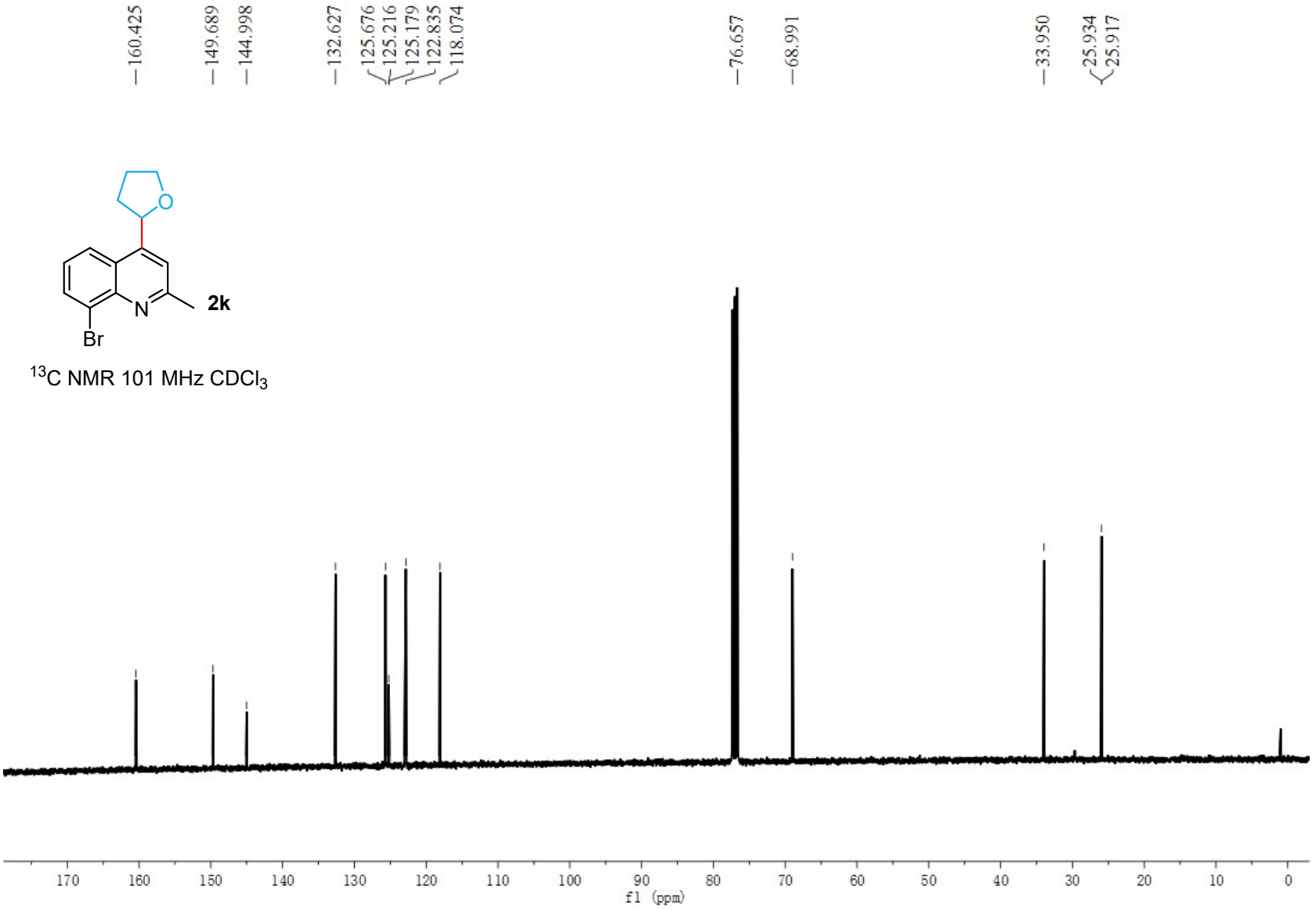
^{1}H NMR 400 MHz $CDCl_3$



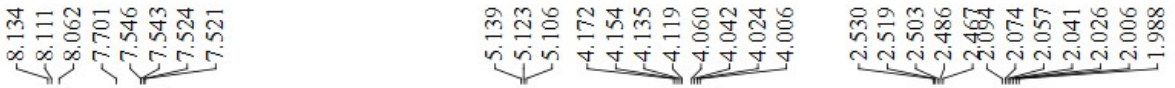
^{13}C NMR 101 MHz $CDCl_3$

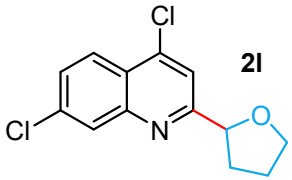


^{1}H NMR 400 MHz $CDCl_3$



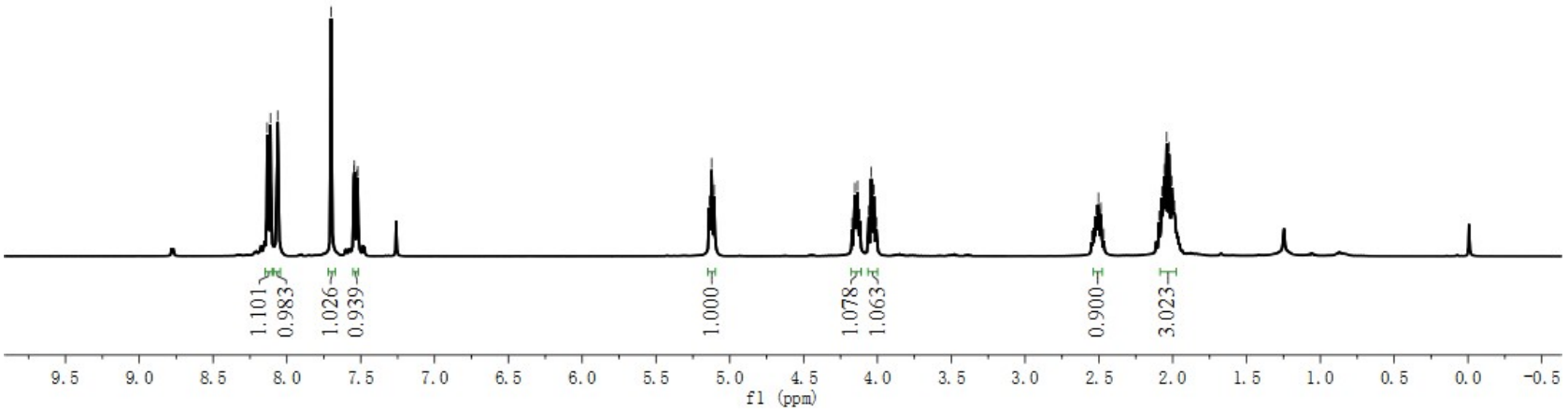
^{13}C NMR 101 MHz $CDCl_3$

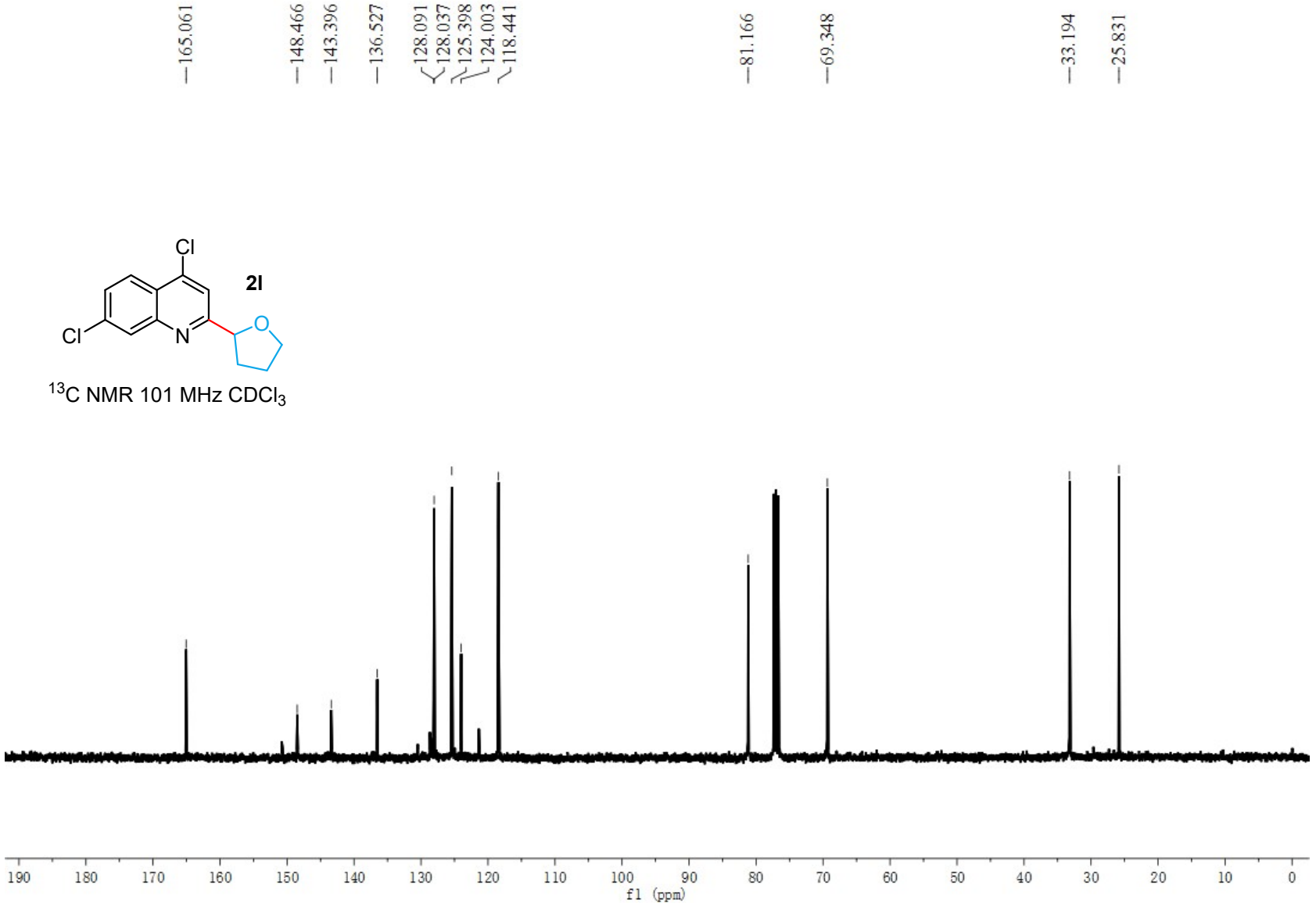


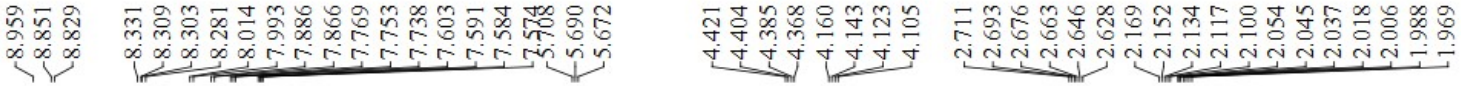


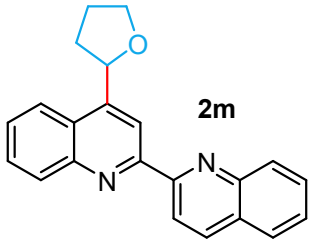
2l

^{1}H NMR 400 MHz $CDCl_3$



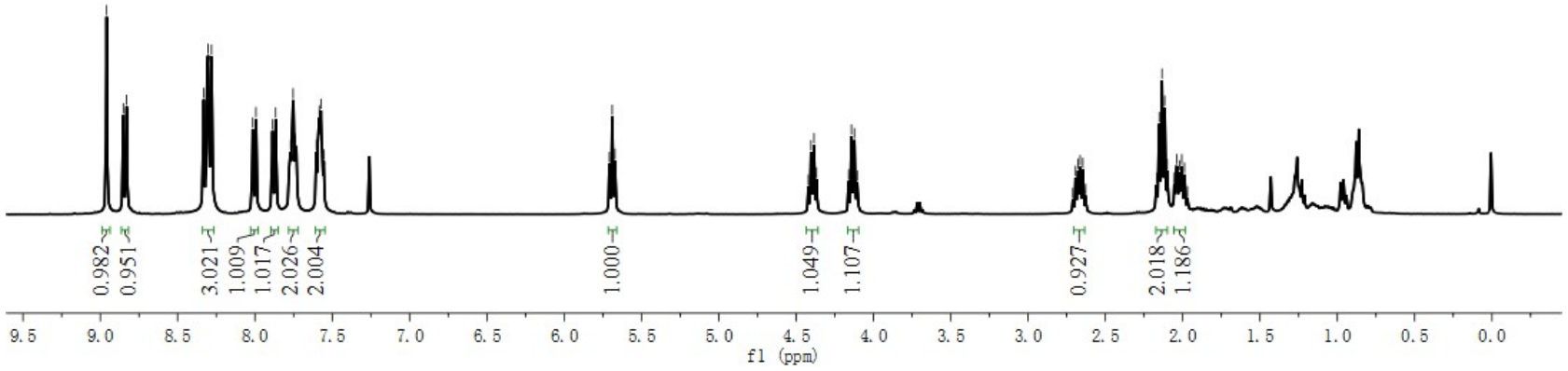

165.061
148.466
143.396
136.527
128.091
128.037
125.398
124.003
118.441
81.166
69.348
33.194
25.831
Cl
Cl
N
O
2l
13C NMR 101 MHz CDCl3
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

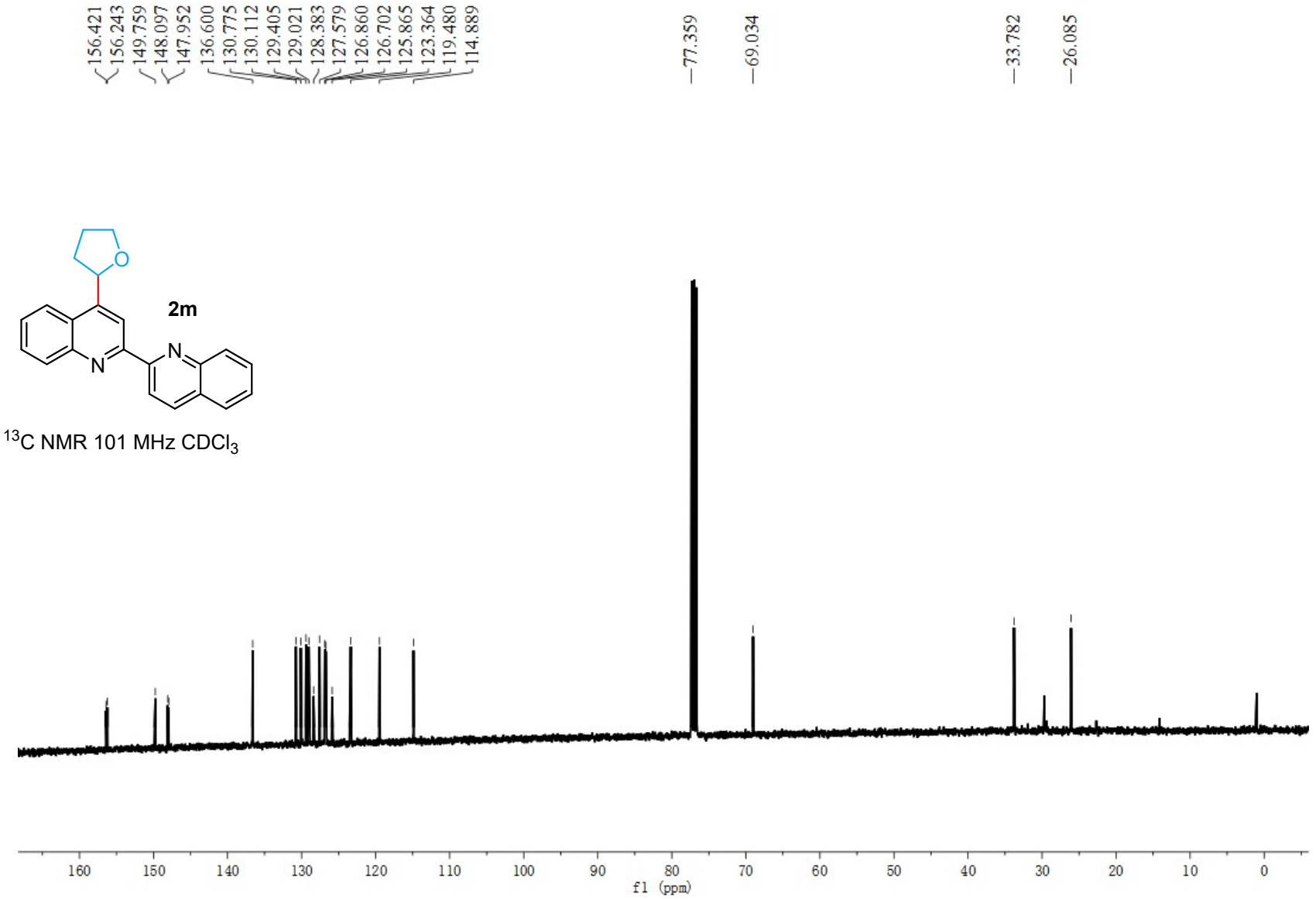




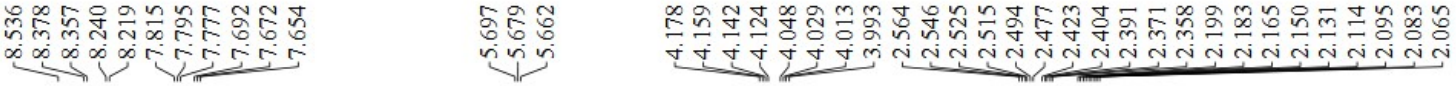
2m

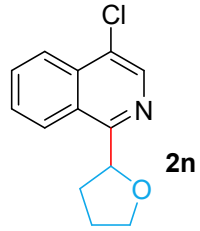
^{1}H NMR 400 MHz $CDCl_3$





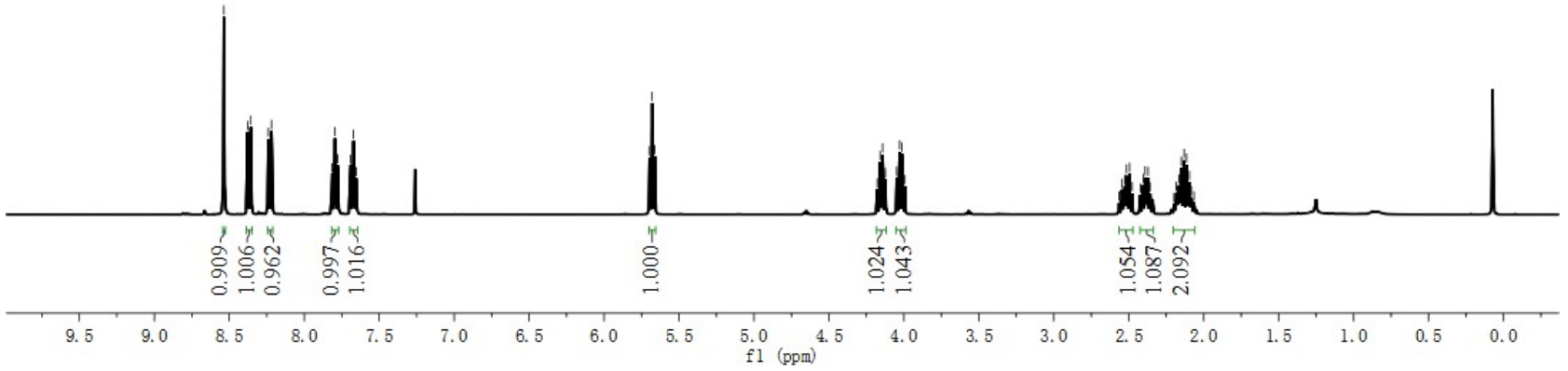
^{13}C NMR 101 MHz $CDCl_3$

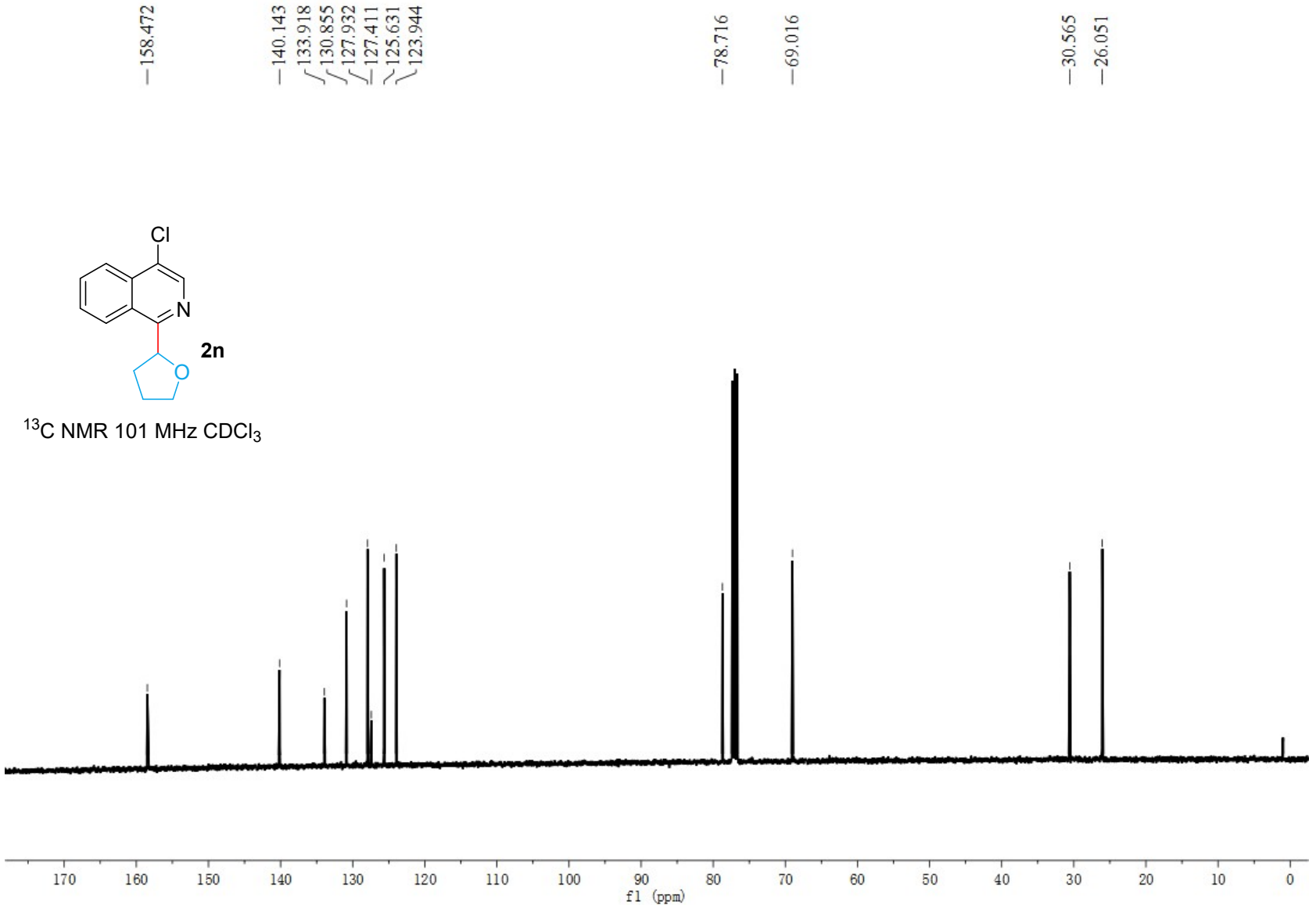


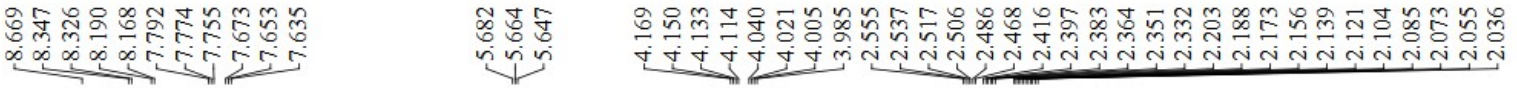


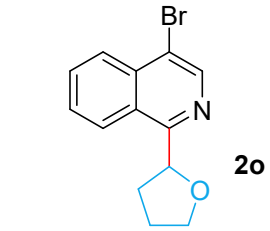
2n

^{1}H NMR 400 MHz $CDCl_3$



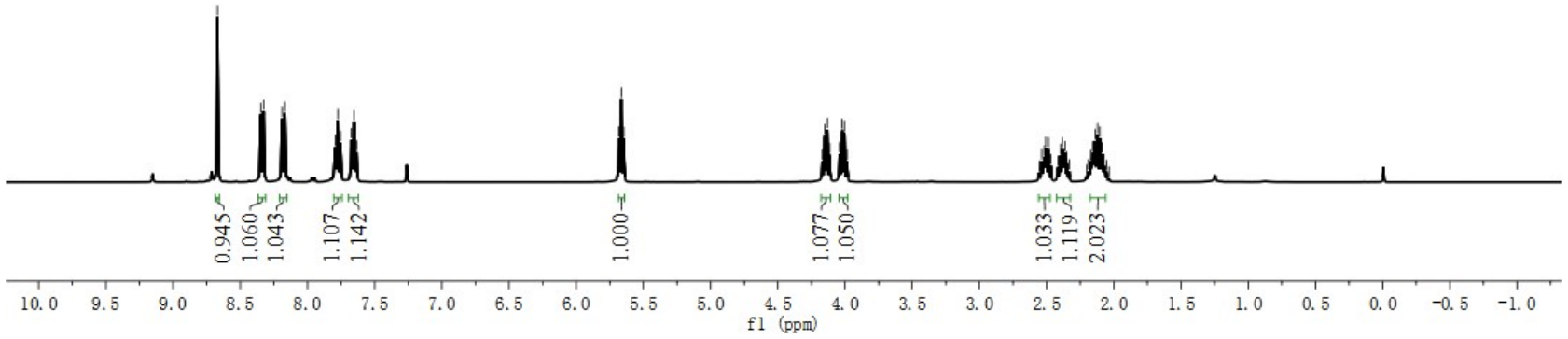

158.472
140.143
133.918
130.855
127.932
127.411
125.631
123.944
78.716
69.016
30.565
26.051
Cl
N
O
2n
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

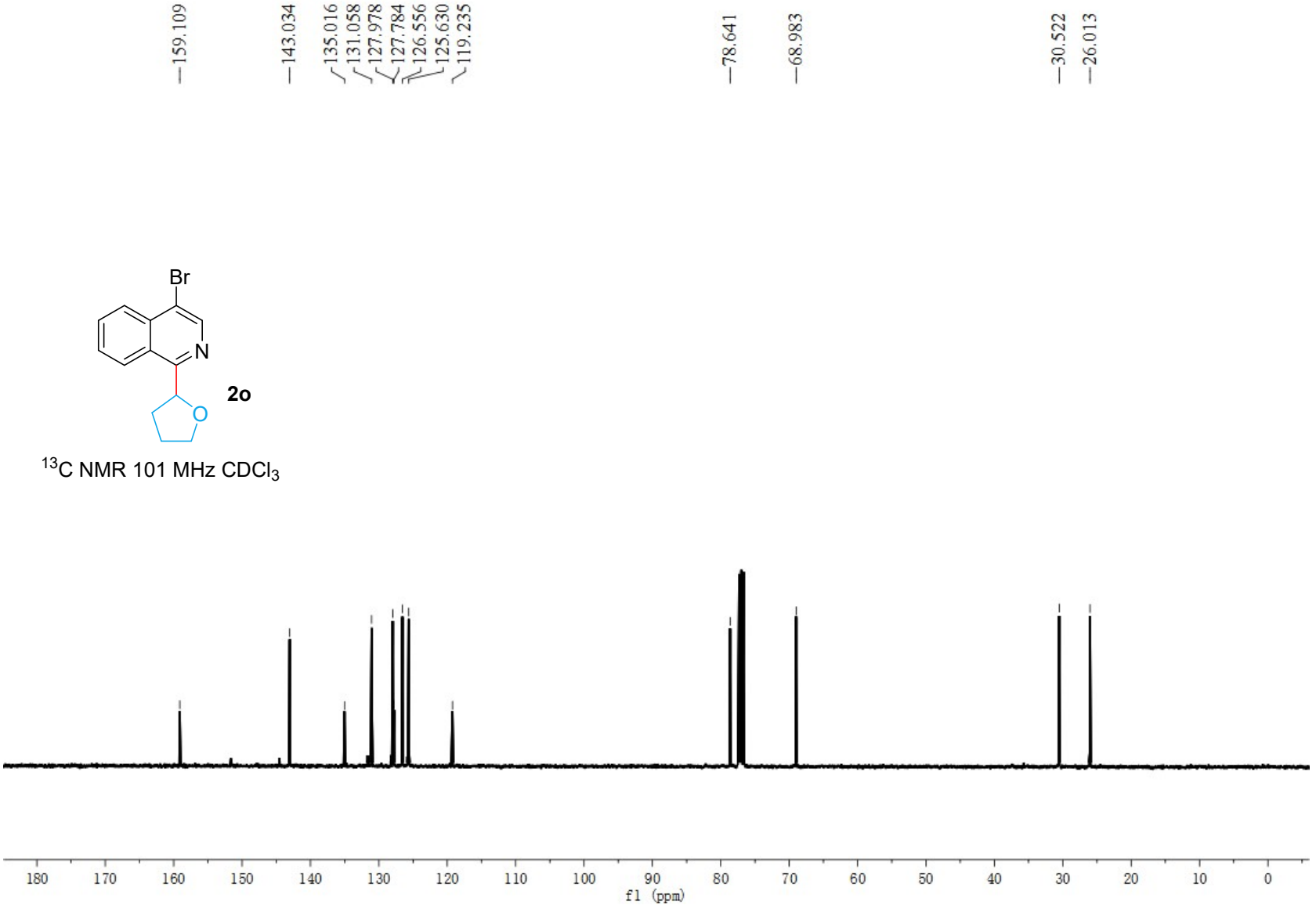


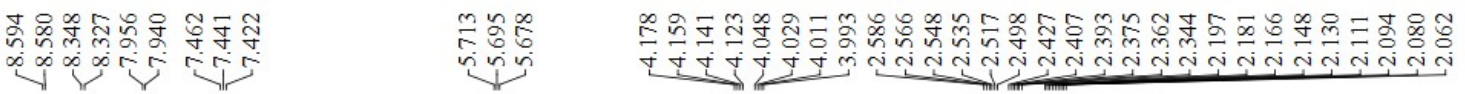


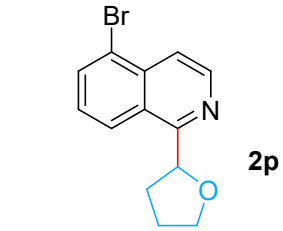
2o

^{1}H NMR 400 MHz $CDCl_3$



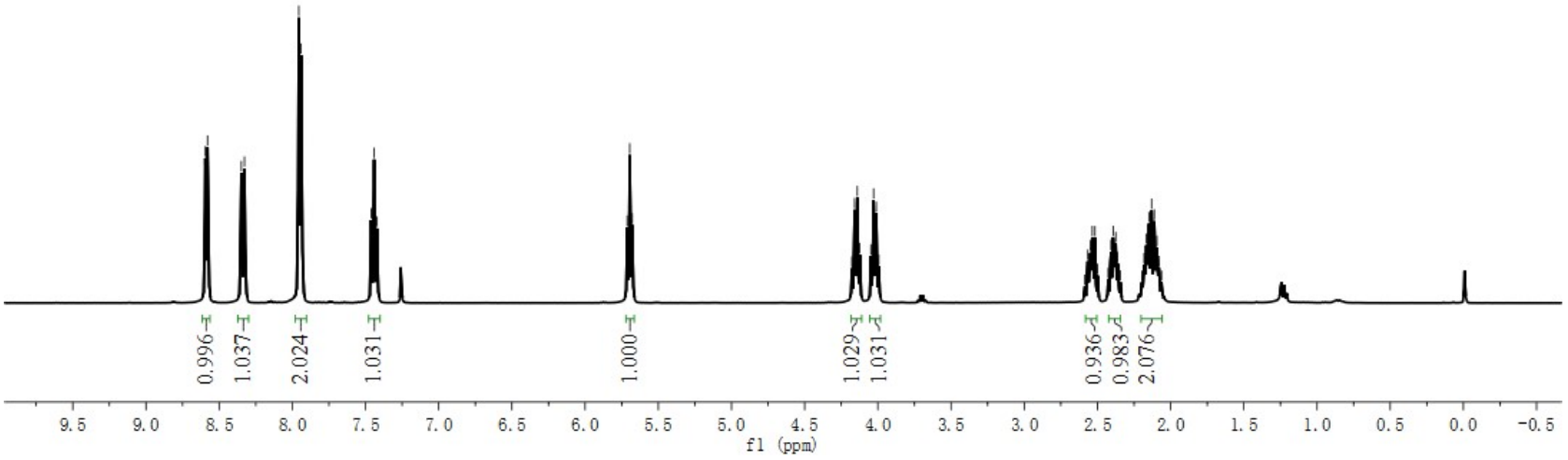

159.109
143.034
135.016
131.058
127.978
127.784
126.556
125.630
119.235
78.641
68.983
30.522
26.013
Br
N
O
2o
^{13}C NMR 101 MHz $CDCl_3$
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

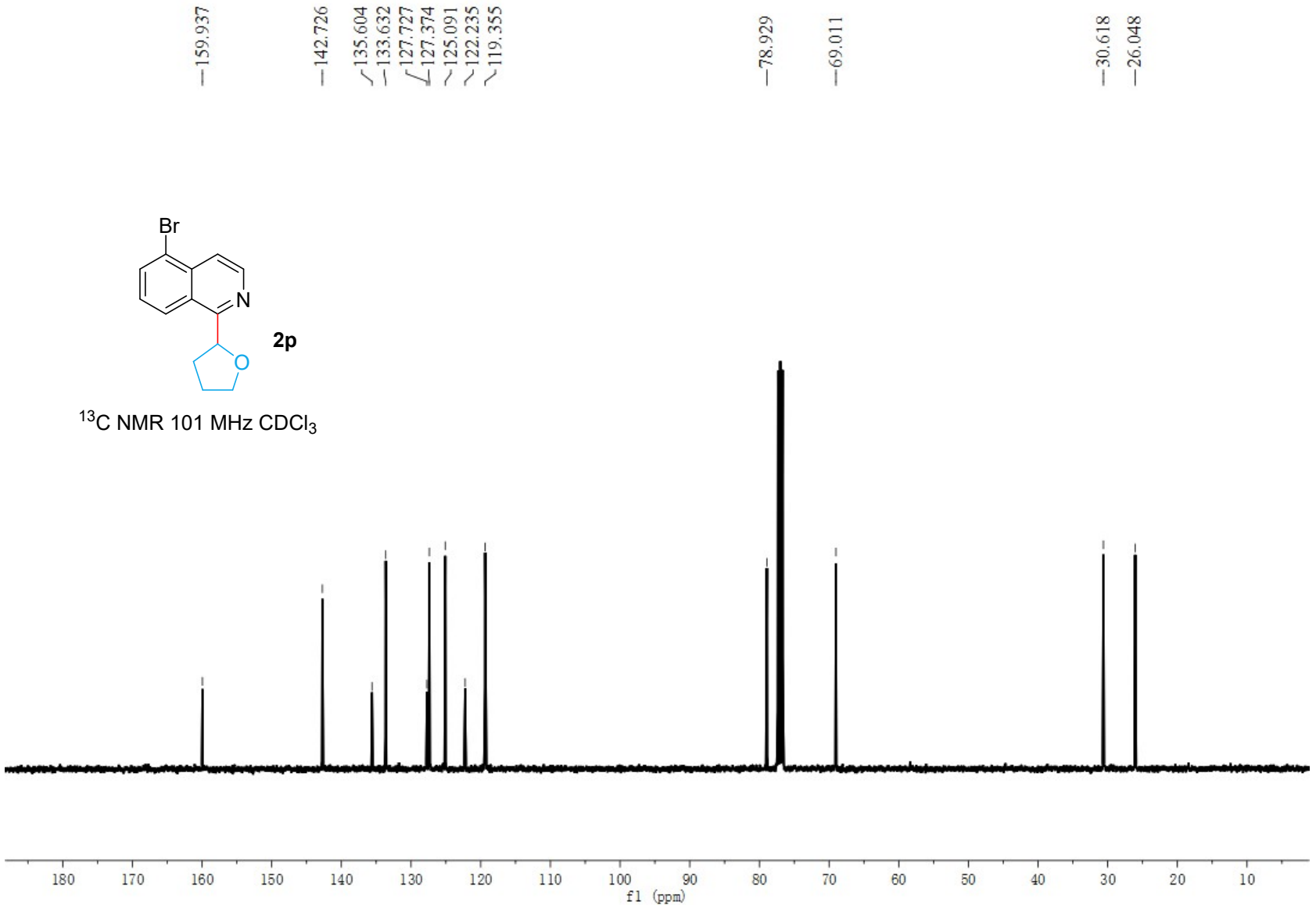


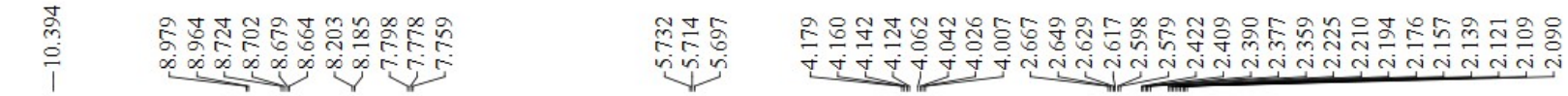


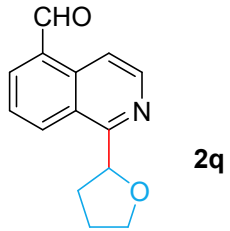
2p

^{1}H NMR 400 MHz $CDCl_3$



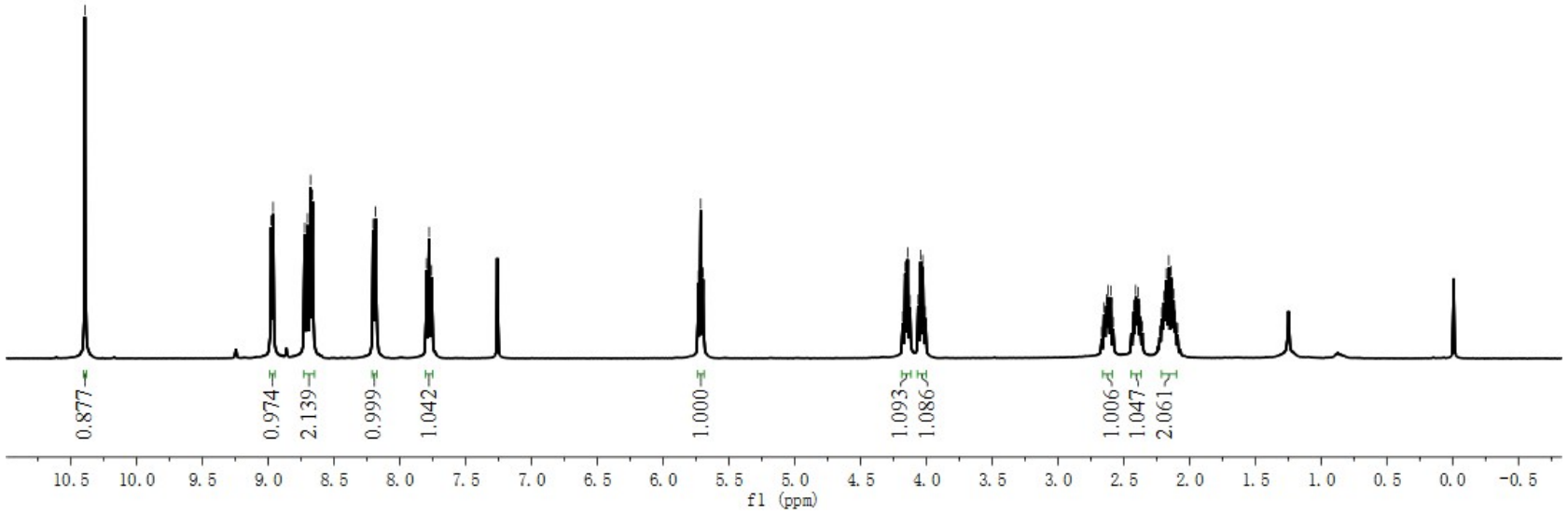

159.937
142.726
135.604
133.632
127.727
127.374
125.091
122.235
119.355
78.929
69.011
30.618
26.048
Br
N
O
2p
^{13}C NMR 101 MHz $CDCl_3$
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

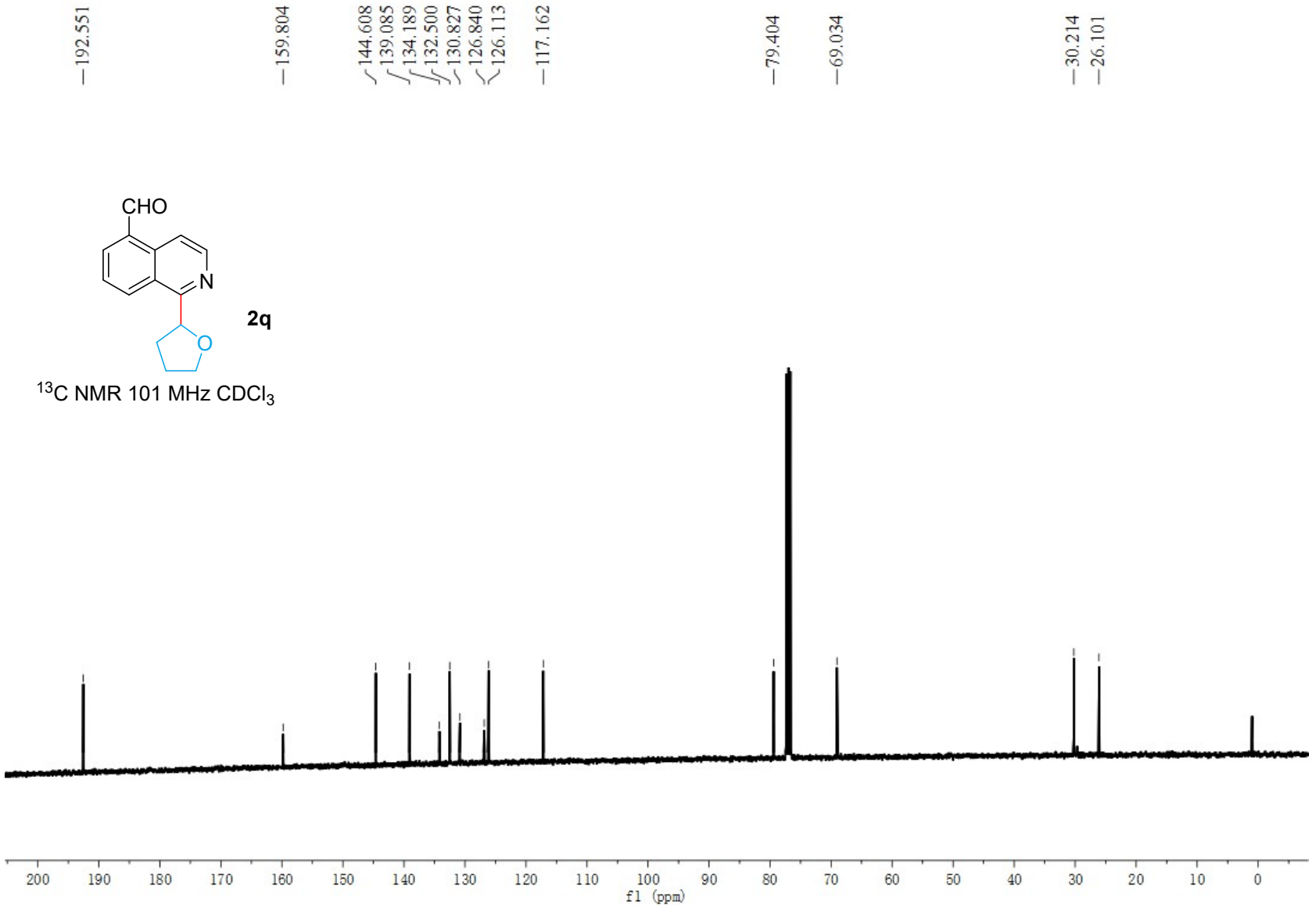


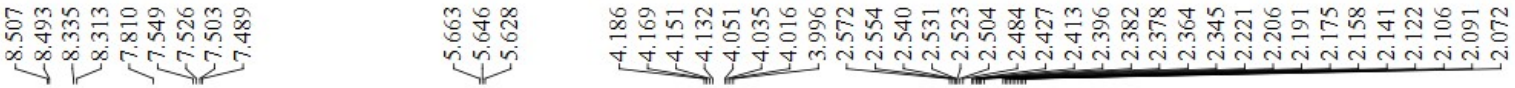


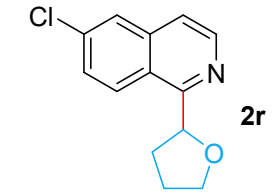
2q

^{1}H NMR 400 MHz $CDCl_3$



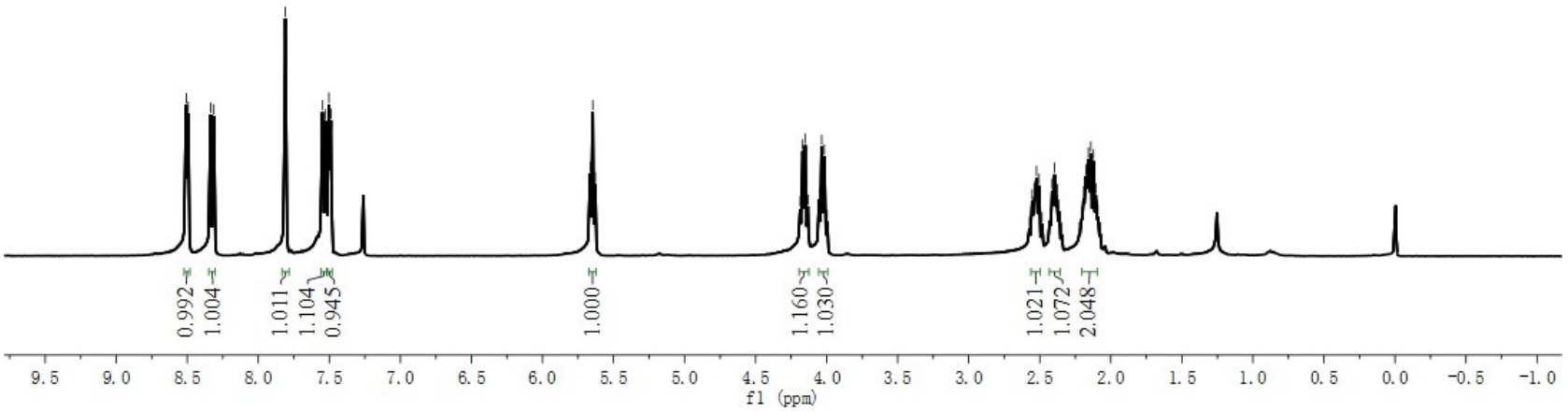

192.551
159.804
144.608
139.085
134.189
132.500
130.827
126.840
126.113
117.162
79.404
69.034
30.214
26.101
CHO
N
O
2q
^{13}C NMR 101 MHz $CDCl_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

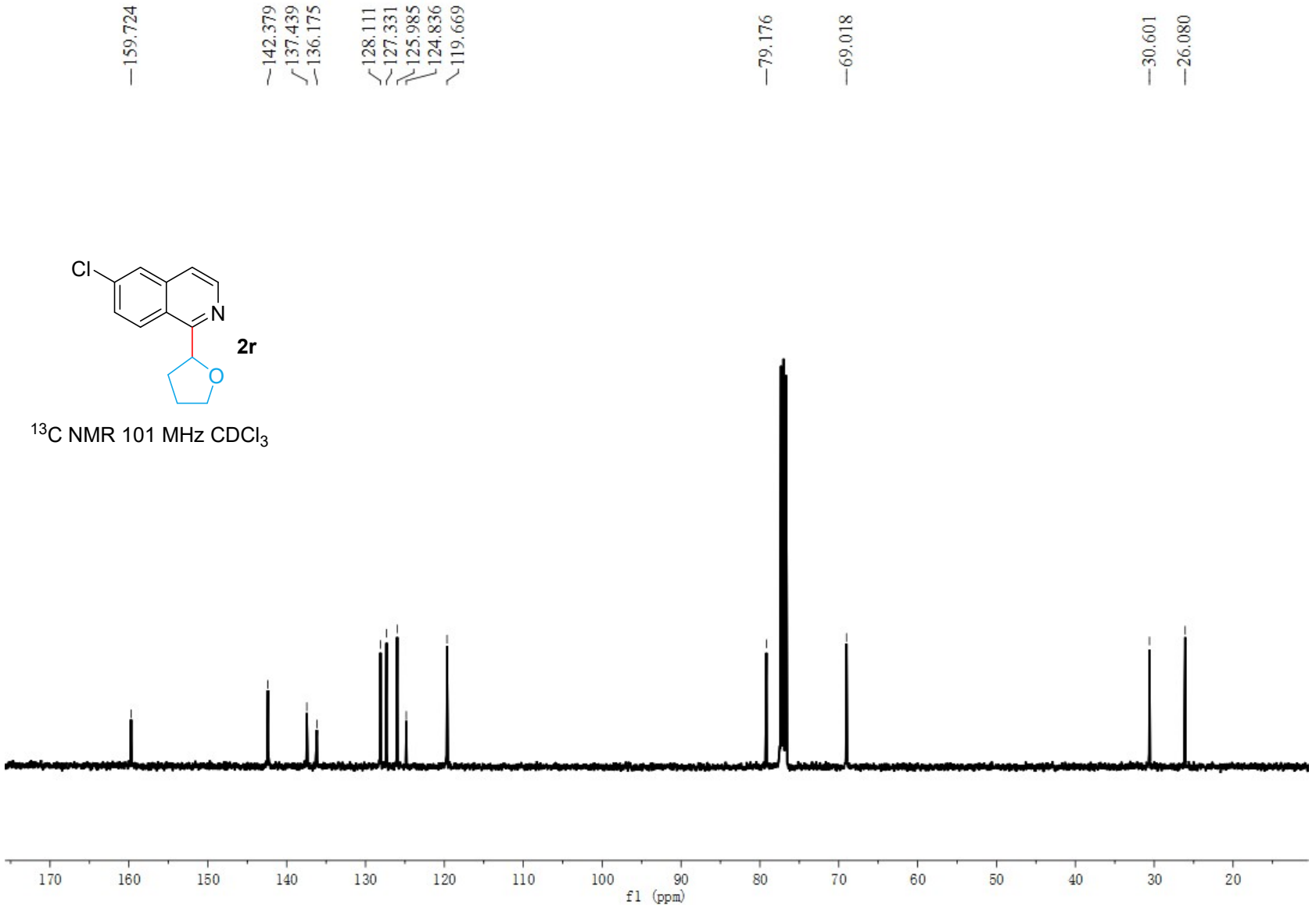


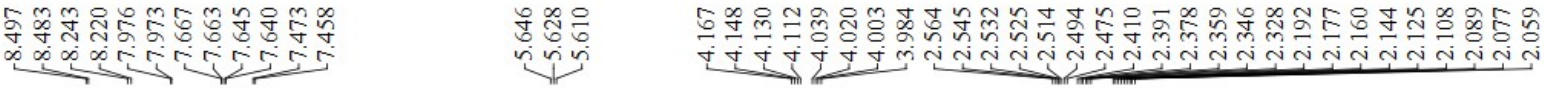


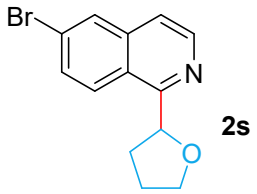
2r

^{1}H NMR 400 MHz $CDCl_3$



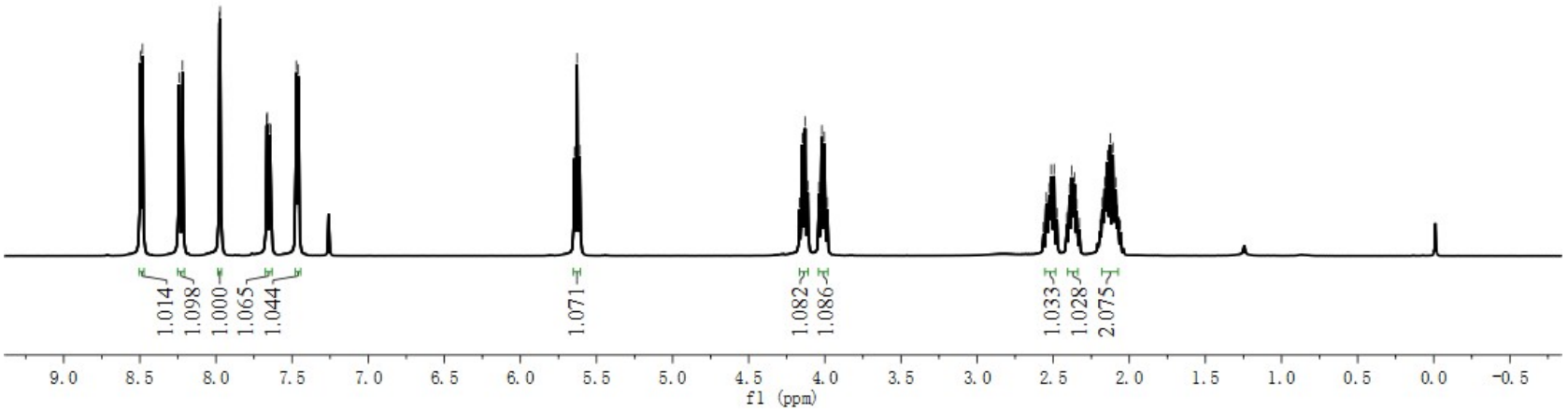

159.724
142.379
137.439
136.175
128.111
127.331
125.985
124.836
119.669
79.176
69.018
30.601
26.080
Cl
N
O
2r
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)

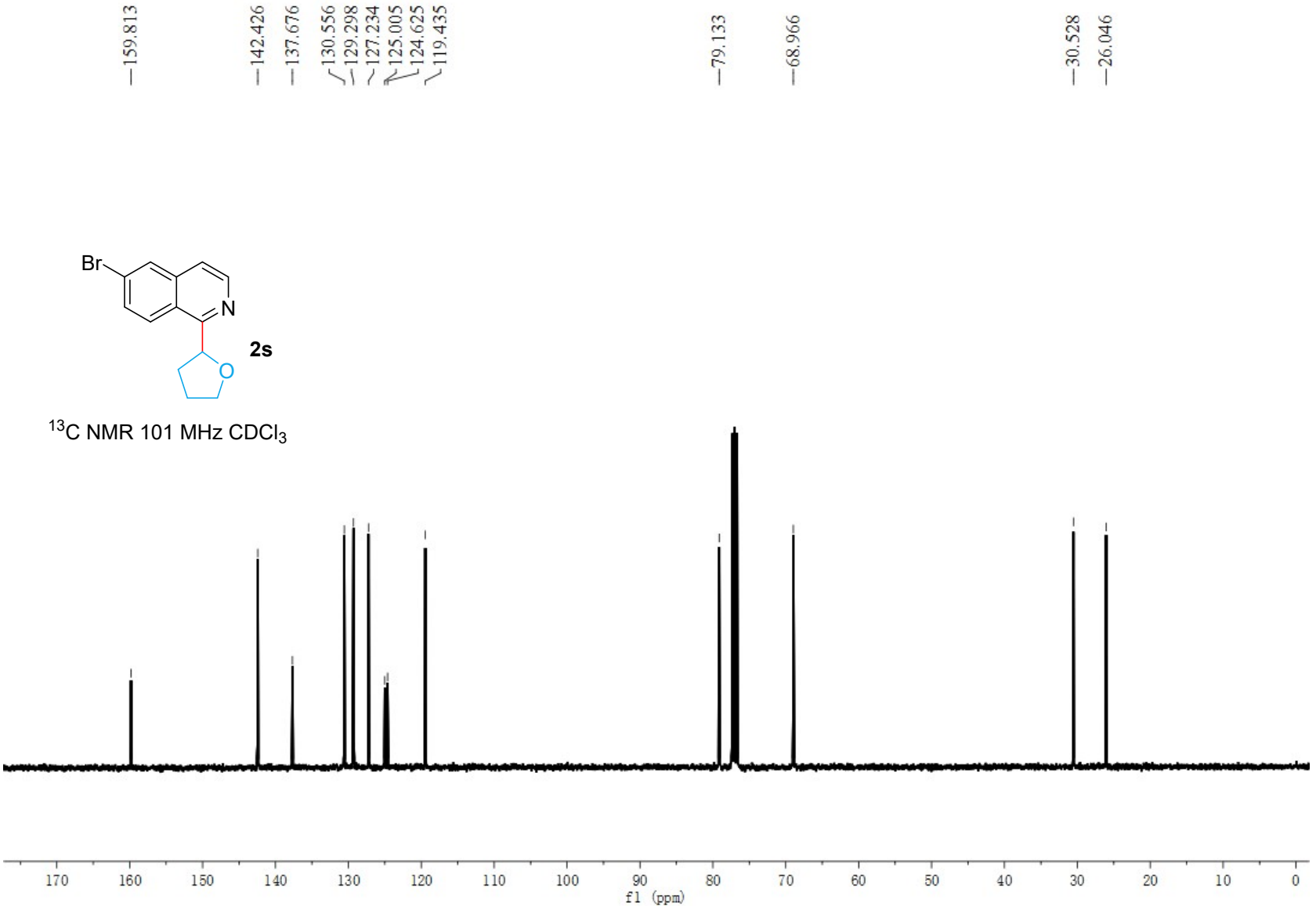


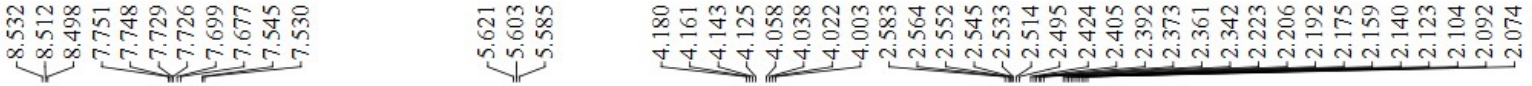


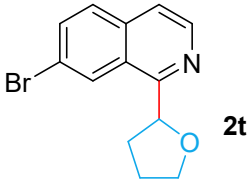
2s

^{1}H NMR 400 MHz $CDCl_3$



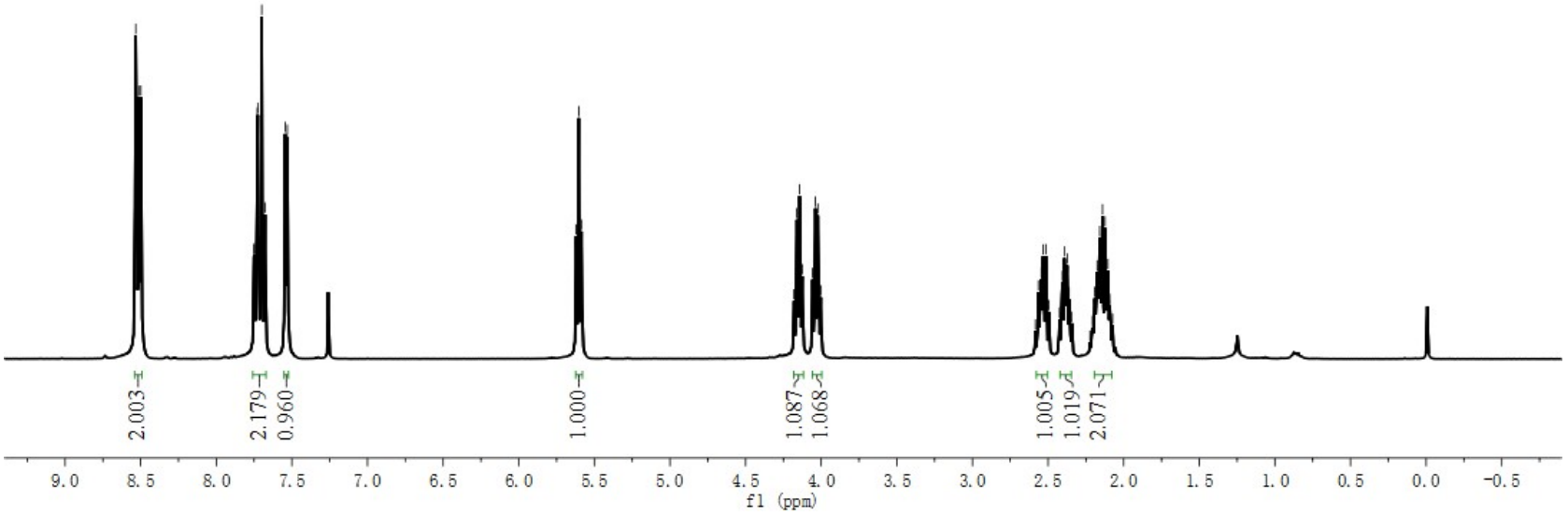

159.813
142.426
137.676
130.556
129.298
127.234
125.005
124.625
119.435
79.133
68.966
30.528
26.046
Br
N
O
2s
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

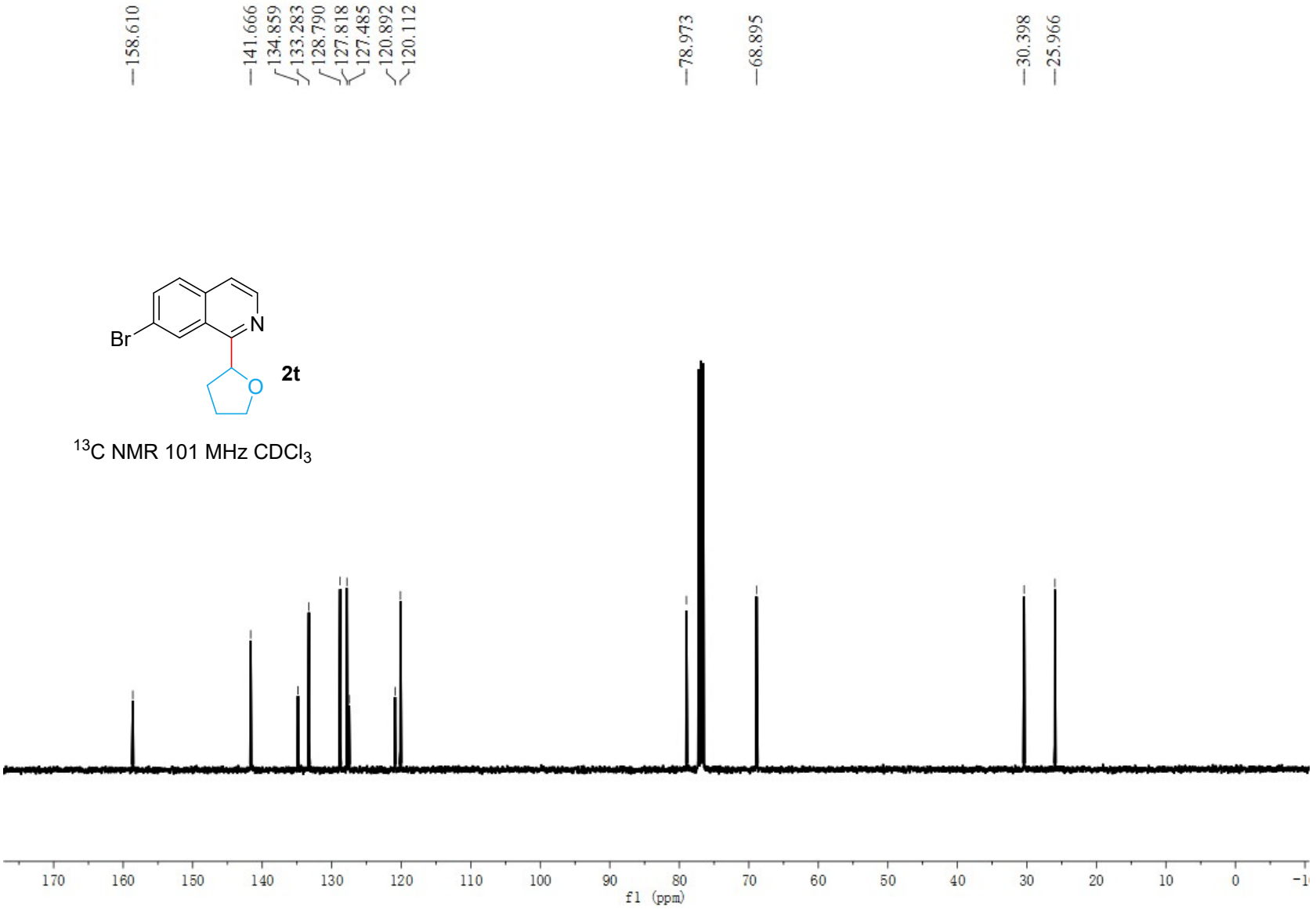


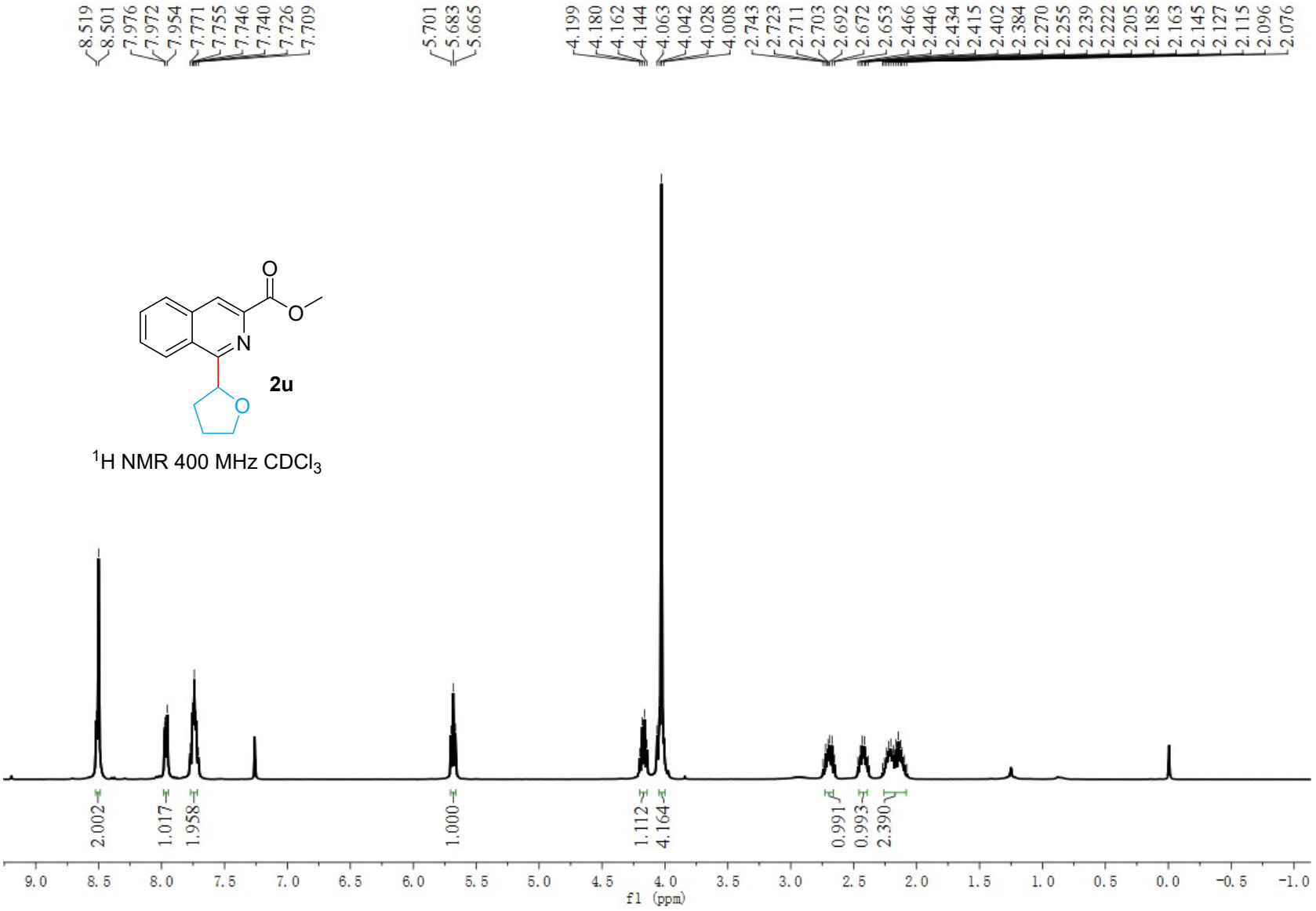


2t

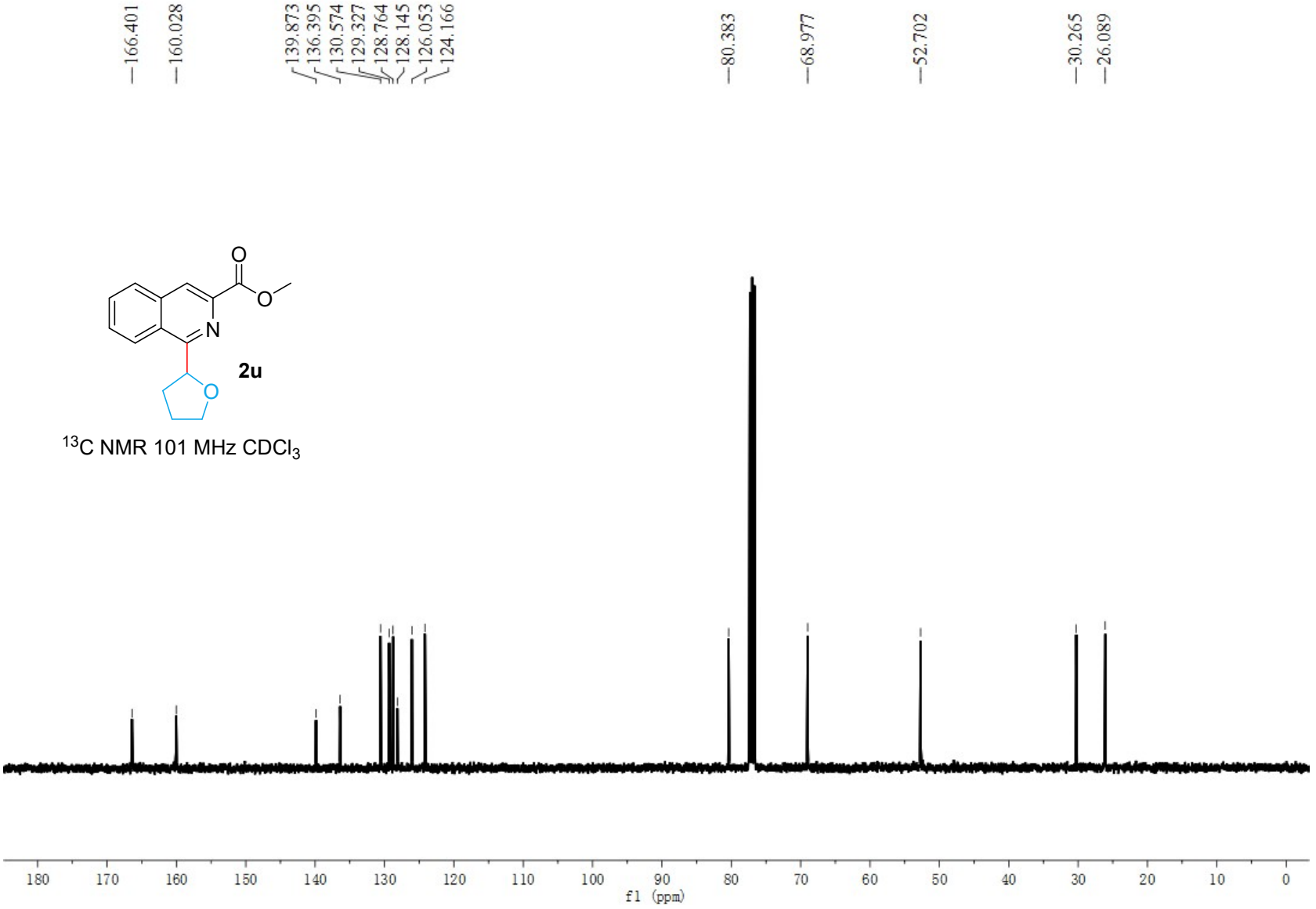
^{1}H NMR 400 MHz $CDCl_3$



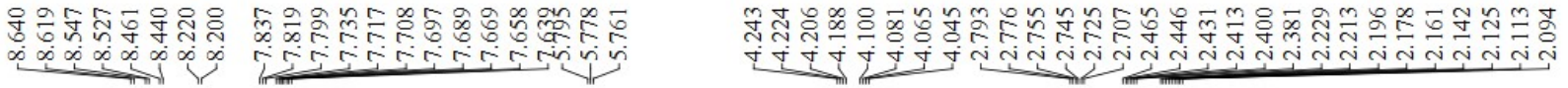

158.610
141.666
134.859
133.283
128.790
127.818
127.485
120.892
120.112
78.973
68.895
30.398
25.966
Br
N
O
2t
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

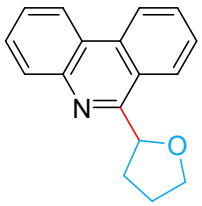


^{1}H NMR 400 MHz $CDCl_3$



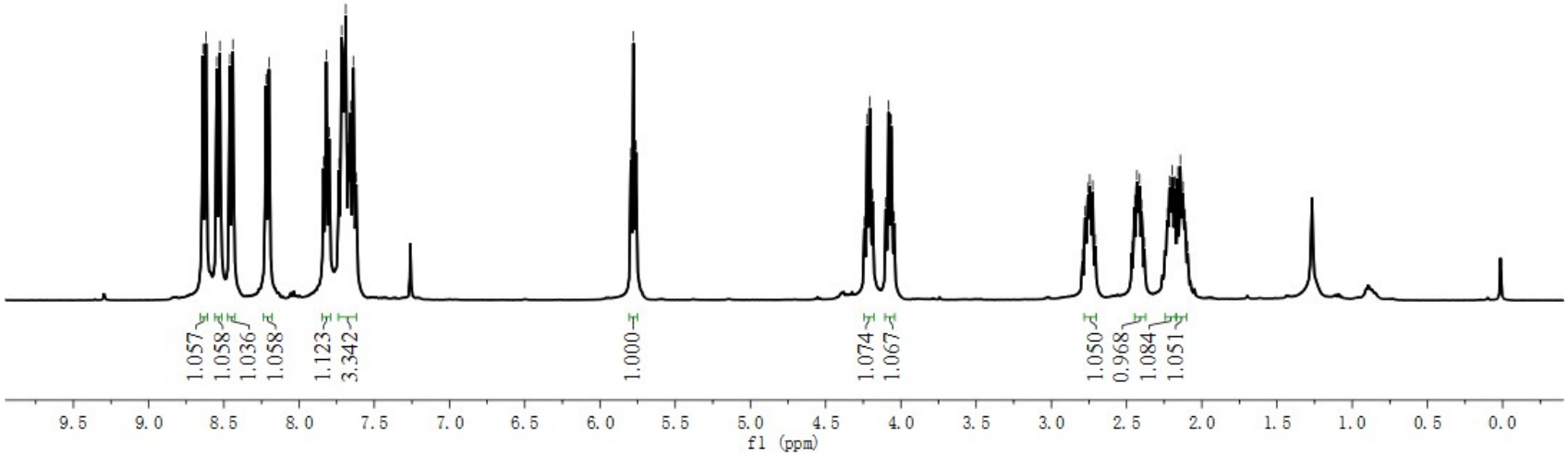
^{13}C NMR 101 MHz $CDCl_3$



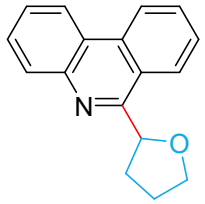


2v

^{1}H NMR 400 MHz $CDCl_3$

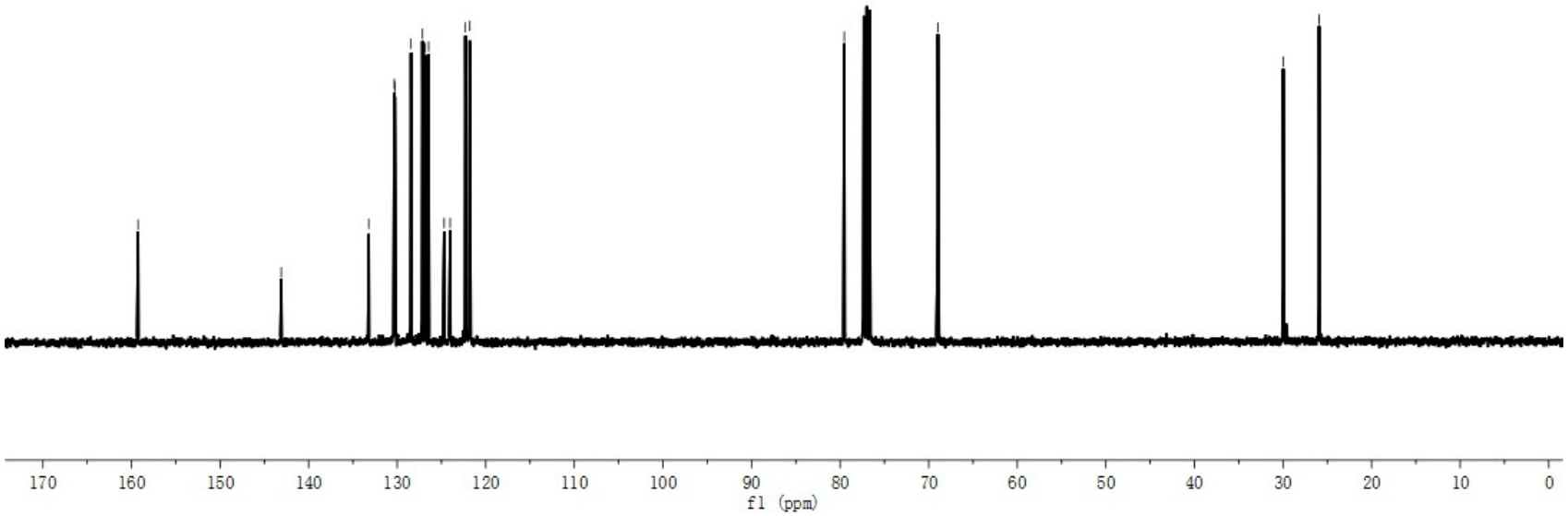


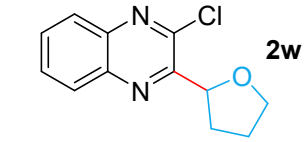
159.248
143.087
133.209
130.329
130.264
128.440
127.145
126.839
126.445
124.694
124.025
122.296
121.799
79.529
68.960
29.977
25.927



2v

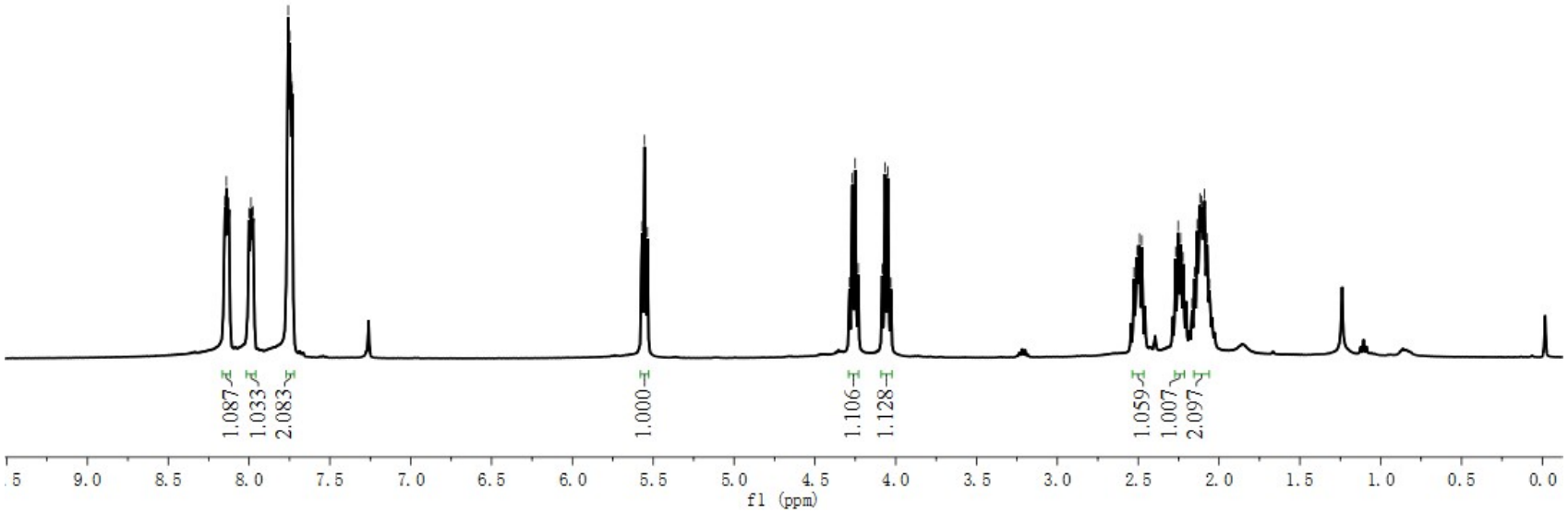
^{13}C NMR 101 MHz $CDCl_3$



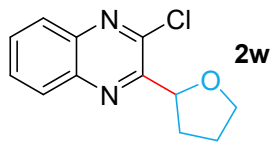


2w

^{1}H NMR 400 MHz $CDCl_3$

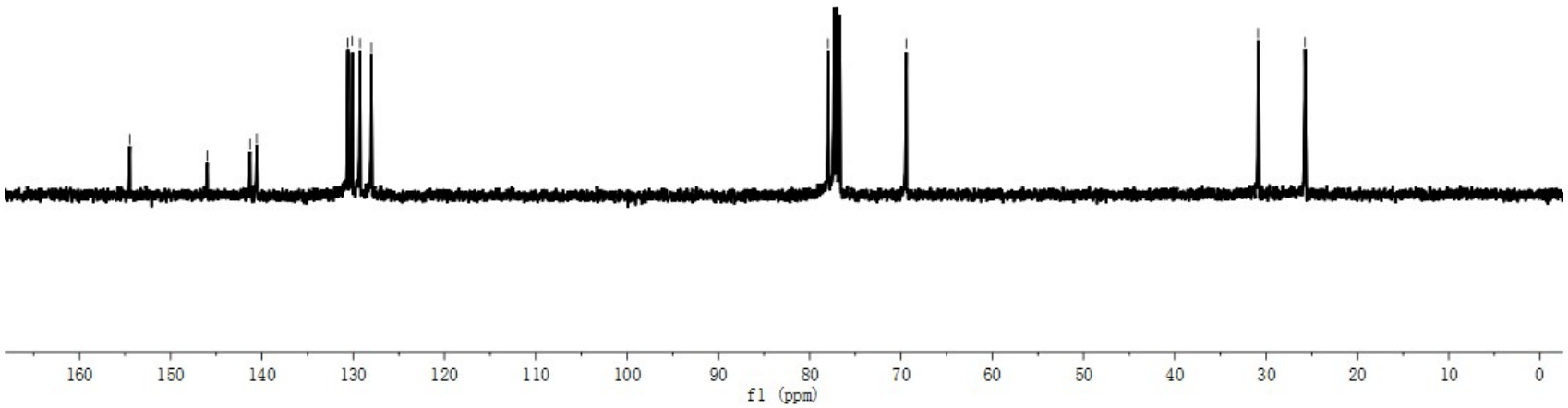


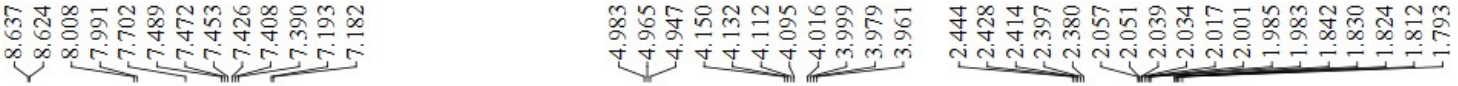
154.472
145.999
141.299
140.572
130.580
130.104
129.257
128.006
77.973
69.425
30.879
25.738

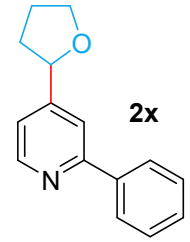


2w

^{13}C NMR 101 MHz $CDCl_3$

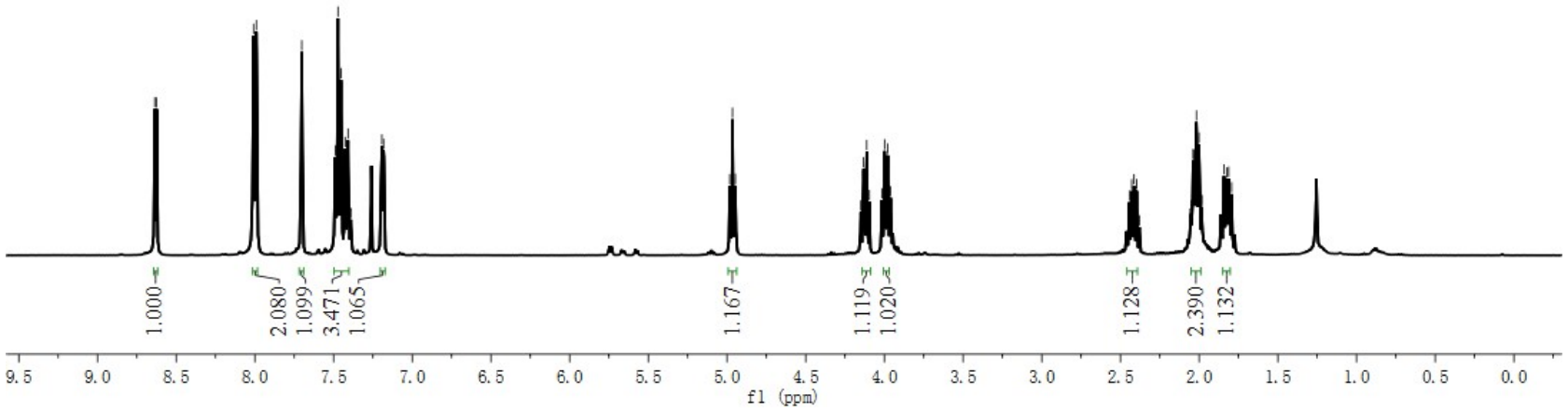


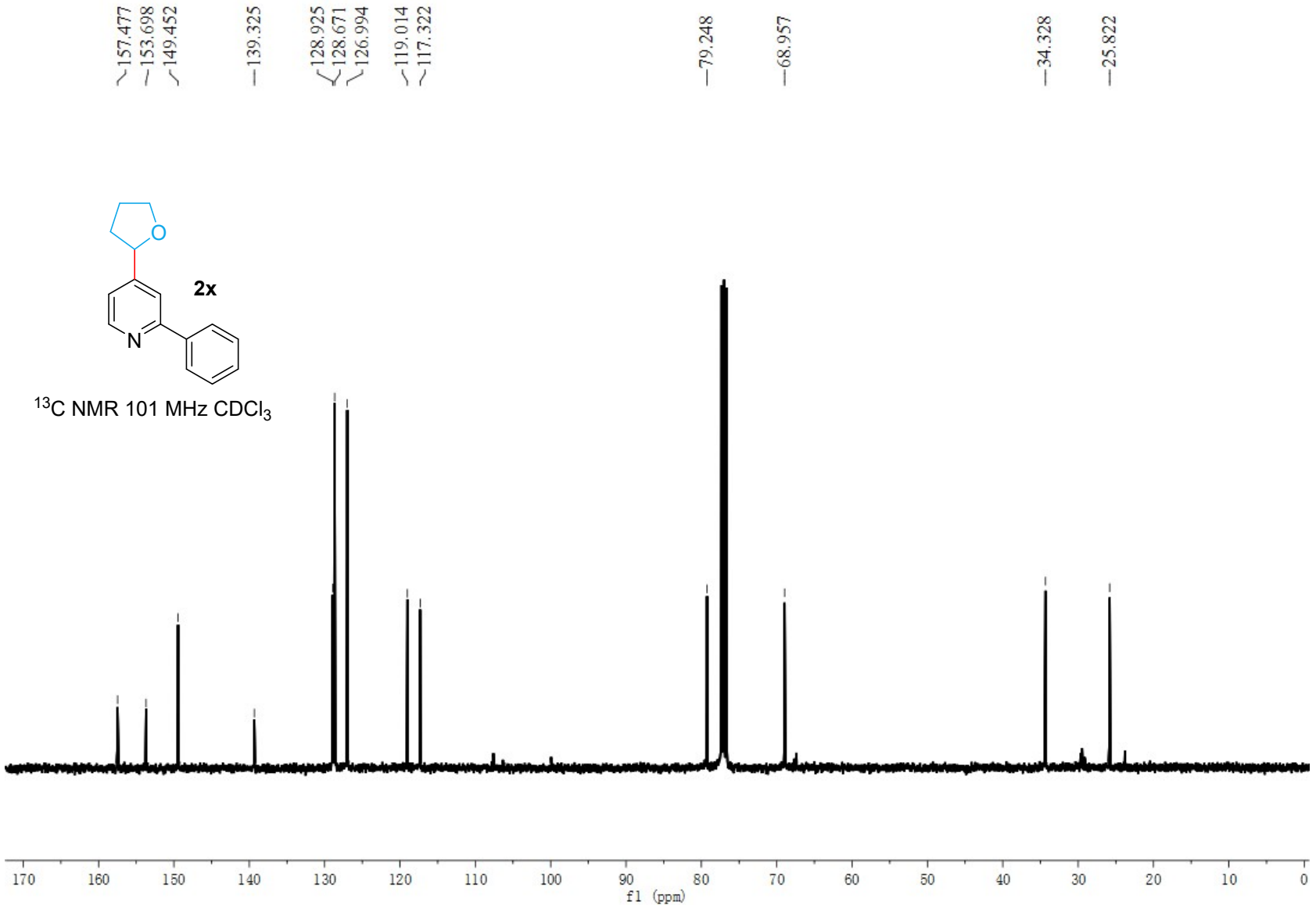




2x

^{1}H NMR 400 MHz $CDCl_3$




157.477
153.698
149.452
139.325
128.925
128.671
126.994
119.014
117.322
79.248
68.957
34.328
25.822
O
N
2x
^{13}C NMR 101 MHz $CDCl_3$
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)